2. Subbasin Assessment – Water Quality Concerns and Status

Section 303(d) of the Clean Water Act (CWA) states that waters unable to support their beneficial uses, and that do not meet water quality standards, must be listed as water quality limited waters. Subsequently, these waters are required to have TMDLs developed to bring them into compliance with water quality standards.

2.1 Water Quality Limited Assessment Units Occurring in the Subbasin

Water quality is now assessed on the basis of assessment units, some of which end up being listed as impaired. Assessment units and a list of the impaired waters for the subbasin are discussed in the following.

About Assessment Units

Assessment units now define all the waters of the state of Idaho. These units and the methodology used to describe them can be found in the WBAGII (Grafe et al. 2002). Assessment units (AUs) are groups of similar streams that have similar land use practices, ownership, or land management. Stream order, however, is the main basis for determining AUs—although ownership and land use can change significantly, the AU remains the same.

Using assessment units to describe water bodies offers many benefits, the primary benefit being that all the waters of the state are now defined consistently. In addition, using AUs fulfills the fundamental requirement of EPA's 305(b) report, a component of the Clean Water Act wherein states report on the condition of all the waters of the state. Because AUs are a subset of water body identification numbers, there is now a direct tie to the water quality standards for each AU, so that beneficial uses defined in the water quality standards are clearly tied to streams on the landscape.

However, the new framework of using AUs for reporting and communicating needs to be reconciled with the legacy of 303 (d) listed streams. Due to the nature of the court-ordered 1994 303(d) listings, and the subsequent 1998 303(d) list, all segments were added with boundaries from "headwater to mouth." In order to deal with the vague boundaries in the listings, and to complete TMDLs at a reasonable pace, DEQ set about writing TMDLs at the watershed scale (HUC), so that all the waters in the drainage are and have been considered for TMDL purposes since 1994.

The boundaries from the 1998 303(d) listed segments have been transferred to the new AU framework using an approach quite similar to how DEQ has been writing subbasin assessments and TMDLs. All AUs contained in the listed segment were carried forward to the 2002 303(d) listings in Section 5 of the Integrated Report. AUs not wholly contained within a previously listed segment, but partially contained (even minimally), were also included on the 303(d) list. This was necessary to maintain the integrity of the 1998 303(d) list and to maintain continuity with the TMDL program. These new AUs will lead to better assessment of water quality listing and de-listing.

When assessing new data that indicate full support, only the AU that the monitoring data represents will be removed (de-listed) from the §303(d) list (Section 5 of the Integrated Report).

Listed Waters

Table 10 shows the pollutants listed and the basis for listing for each §303(d) listed AU in the subbasin. Figure 14 shows the location of each 303(d) listed water body within the basin. Not all of the water bodies will require a TMDL, as will be discussed later. However, a thorough investigation, using the available data, was performed before this conclusion was made. This investigation, along with a presentation of the evidence of non-compliance with standards for several other tributaries, is contained in the following sections.

Table 10. §303(d) Segments in the King Hill-C.J. Strike Reservoir Subbasin.

Water Body Name	Assessment Unit ID Number	1998 §303(d) Boundaries	Pollutants	Listing Basis[1]
Snake River	ID17050101SW005_07	King Hill to Hwy 51 Bridge (Loveridge Bridge)	Sediment	305(b) Appendix D, 1994 §303(d) List
C.J. Strike Reservoir	ID17050101SW001_02, 05, 06, 07	Entire Reservoir	Pesticides, Nutrients	305(b) Appendix D
Alkali Creek	ID17050101SW013_02, 03	Headwaters to Snake River	Sediment	305(b) Appendix D
Bennett Creek	ID17050101SW016_02, 03	Headwaters to Snake River	Unknown[2]	Unknown
Browns Creek	ID17050101SW003_02, 03, 04 ID17050101SW004_02, 03	Headwaters to Snake River	Sediment	305(b) Appendix D
Cold Springs Creek	ID17050101SW014_03	Ryegrass Creek to Snake River	Unknown	305(b) Appendix D
Deadman Creek	ID17050101SW008_02, 03	Headwaters to Snake River	Sediment	305(b) Appendix D
Little Canyon Creek	ID17050101SW012_02, 03, 03a	Headwaters to Snake River	Sediment, Flow Alteration	305(b) Appendix D
Ryegrass Creek	ID17050101SW015_02	Headwaters to Cold Springs Creek	Sediment	305(b) Appendix D
Sailor Creek	ID17050101SW006_02, 03, 04	Headwaters to Snake River	Sediment	305(b) Appendix D

[1]Based on 1996 §303(d) List
[2] Data suggesting beneficial use impairment are available, but impairment has not been linked to a specific pollutant

2.2 Applicable Water Quality Standards

Idaho adopts both narrative and numeric water quality standards to protect public health and welfare, enhance the quality of water, and protect biological integrity. By designating the beneficial use or uses for water bodies, Idaho has created a mechanism for setting criteria necessary to protect those uses and prevent degradation of water quality through anti-degradation provisions. According to IDAPA 58.01.02.050 (02)a, "wherever attainable, surface waters of the state shall be protected for beneficial uses which for surface waters includes all recreational use in and on the water surface and the preservation and propagation of desirable species of aquatic life."

Beneficial use support is determined by DEQ through its water body assessment process. Table 11 contains a listing of the designated beneficial uses for each listed segment in the subbasin. Additionally, agricultural and industrial water supply, wildlife habitat, and aesthetics beneficial uses apply to all surface waters of the state (IDAPA 58.01.02.100.03, 04, 05). Table 12 is a summary of the water quality standards associated with the beneficial uses. For streams with no designated beneficial uses, coldwater aquatic life and recreation are presumed to be uses. Table 12 and the following discussion focuses on beneficial uses and the water quality criteria, both narrative and numeric, that apply to each of the listed water bodies. A more detailed explanation of the numeric water quality targets developed as an interpretation of the narrative standards for nutrients and sediment can be found in the Water Quality Targets section (page 160) of this TMDL.

Table 11. King Hill-C.J Strike Reservoir Subbasin Designated Beneficial Uses

Water Body	Designated Uses[1]	1998 §303(d) List[2]
Snake River- King Hill to Hwy 51 Bridge	CW, PCR, DWS, SRW[3]	Sediment
C.J. Strike Reservoir	CW, PCR, DWS, SRW[3]	Nutrients, Pesticides
Alkali Creek	Undesignated	Sediment
Bennett Creek	Undesignated	Unknown
Browns Creek	Undesignated	Sediment
Cold Springs Creek	Undesignated	Unknown
Deadman Creek	Undesignated	Sediment
Little Canyon Creek	Undesignated	Sediment, Flow Alteration
Ryegrass Creek	Undesignated	Sediment
Sailor Creek	Undesignated	Sediment

[1]CW – Cold Water, SS – Salmonid Spawning, PCR – Primary Contact Recreation, SCR – Secondary Contact Recreation, AWS – Agricultural Water Supply, DWS – Domestic Water Supply

[2]Refers to a list created by the State of Idaho in 1998. Monitoring data was used to identify water bodies in Idaho that did not fully support at least one beneficial use. This list is required under section 303 subsection "d" of the Clean Water Act.

[3]Special Resource Water. A waters designated as a special resource water meets at least one of the following criteria: 1) outstanding quality for recreation and aquatic life; 2) unique ecological significance; 3) outstanding recreational or aesthetic qualities; 4) protection is paramount to the interest of the people in Idaho; 5) within a wild and scenic river system, state or national park system or wildlife refuge; and 6) intensive protection is necessary to maintain an existing, but jeopardized beneficial use.

Table 12. Water Quality Standards Associated with Beneficial Uses

Pollutant & IDAPA Citation	Beneficial Use(s) to Which Standard Applies	Applicable Water Quality Standard
Sediment (58.01.02.200.08)	Cold Water Aquatic Life Salmonid Spawning	Sediment shall not exceed quantities specified in general surface water quality criteria (IDAPA 58.01.02.250 or 252) or, in the absence of specific sediment criteria, quantities which impair designated beneficial uses
Turbidity (58.01.02.250.02.d)	Cold Water Aquatic Life	Less than 50 NTU[2] above background for any given sample or less than 25 NTU for more than 10 consecutive days (below any applicable mixing zone set by DEQ)
Excess Nutrients (58.01.02.200.06)	Cold Water Aquatic Life Contact Recreation	Surface waters shall be free from excess nutrients that can cause visible slime growths or other nuisance aquatic growths impairing designated beneficial uses
Dissolved Oxygen (58.01.02.250.02.a)	Cold Water Aquatic Life Salmonid Spawning	Greater than 6.0 mg/L[2] except in hypolimnion of stratified lakes and reservoirs
pH (58.01.02.250.01.a)	Cold Water Aquatic Life	Hydrogen ion concentration (pH) values within the range of 6.5 to 9.0
Floating, Suspended, or Submerged Matter (Nuisance Algae) (58.01.02.200.05)	Contact Recreation	Surface waters shall be free from floating, suspended, or submerged matter of any kind in concentration causing nuisance or objectionable conditions or that impair designated beneficial uses and be free from oxygen demanding materials in concentrations that would result in an anaerobic water condition
Toxic Substances (Pesticides) (58.01.02.210.01)	Cold Water Aquatic Life Contact Recreation Domestic Water Supply	Refer to the table located in IDAPA 58.01.02.210.01 for a complete listed of the numeric standards
Total Dissolved Gases (58.01.02.250.b)	Cold Water Aquatic Life Salmonid Spawning	The total concentration of dissolved gas not exceeding one hundred ten percent (110%) if saturation at atmospheric pressure at the point of sample collection

[1]NTU = nephlometric turbidity unit
[2]mg/L = milligrams per liter

It is DEQ’s position that habitat modification and flow alteration, which may adversely affect beneficial uses, are not pollutants under § 303(d) of the CWA. Idaho has no water quality standards for habitat or flow, nor are they suitable for estimation of load capacity or load allocations. Because of these practical limitations, TMDLs will not be developed to address habitat modification or flow alteration.

Additionally, the CWA states that, “TMDLs are required to be established for water bodies impaired by a pollutant, but not by pollution.” EPA goes on to say that "EPA does not believe that flow, or lack of flow, is a pollutant as defined by CWA Section 502(6).”

Beneficial Uses

Idaho water quality standards require that surface waters of the state be protected for beneficial uses, wherever attainable (IDAPA 58.01.02.050.02). These beneficial uses are interpreted as existing uses, designated uses, and presumed uses as briefly described in the following paragraphs. The *Water Body Assessment Guidance*, second edition (Grafe et al. 2002) gives a more detailed description of beneficial use identification for use assessment purposes.

Existing Uses

Existing uses under the CWA are "those uses actually attained in the waterbody on or after November 28, 1975, whether or not they are included in the water quality standards." The existing in-stream water uses and the level of water quality necessary to protect the uses shall be maintained and protected (IDAPA 58.01.02.050.02, .02.051.01, and .02.053). Existing uses include uses actually occurring, whether or not the level of quality to fully support the uses exists. A practical application of this concept would be to apply the existing use of salmonid spawning to a water that could support salmonid spawning if spawning occurred on or after November 28, 1975 as determined by the *Water Body Assessment Guidance*, second edition, but salmonid spawning is not occurring due to other factors, such as dams blocking migration.

Designated Uses

Designated uses under the CWA are "those uses specified in water quality standards for each water body or segment, whether or not they are being attained." Designated uses are simply uses officially recognized by the state. In Idaho these include uses such as aquatic life support, recreation in and on the water, domestic water supply, and agricultural uses. Water quality must be sufficiently maintained to meet the most sensitive use. Designated uses may be added or removed using specific procedures provided for in state law, but the effect must not be to preclude protection of an existing higher quality use such as cold water aquatic life or salmonid spawning. Designated uses are specifically listed for water bodies in Idaho in tables in the Idaho water quality standards (see IDAPA 58.01.02.003.27 and .02.109-.02.160 in addition to citations for existing uses).

Presumed Uses

In Idaho, most water bodies listed in the tables of designated uses in the water quality standards do not yet have specific use designations. As shown in Table 13, this is the case for all the §303(d) listed tributaries to the Snake River in the King Hill-C.J. Strike Subbasin. These undesignated uses have yet to be designated. In the interim, and absent information on existing uses, DEQ presumes that most waters in the state will support cold water aquatic life and either primary or secondary contact recreation (IDAPA 58.01.02.101.01). To protect these so-called "presumed uses," DEQ will apply the numeric cold water criteria and primary or secondary contact recreation criteria to undesignated waters. If in addition to these presumed uses, an additional existing use, (e.g., salmonid spawning) exists, because of the requirement to protect levels of water quality for existing uses, then the additional numeric criteria for salmonid spawning would additionally apply (e.g., intergravel dissolved oxygen, temperature). However, if for example, cold water aquatic life is not found to be an existing use, a use designation to that effect is needed before some other aquatic life criteria (such as seasonal cold) can be applied in lieu of cold water criteria (IDAPA 58.01.02.101.01).

Table 13 shows the designated/presumed uses as well as the documented existing uses for the each §303(d) listed water body in the King Hill-C.J. Strike Subbasin. It should be noted that if the designated use is more protective than the existing use, the designated use must be protected, regardless of whether or not the use has been documented.

Table 13. King Hill-C.J. Strike Subbasin, Beneficial uses of §303(d) listed streams.

Water Body	Designated Uses[1]	Existing Uses
Snake River (Clover Creek to Browns Creek)	CW, PCR, DWS, SRW	CW, PCR, DWS, SRW
C.J. Strike Reservoir	CW, PCR, DWS, SRW	CW, PCR, DWS, SRW
Alkali Creek	Undesignated	CW, SCR
Bennett Creek	Undesignated	SS, CW, SCR
Browns Creek	Undesignated	CW, SCR
Cold Springs Creek	Undesignated	SS, CW, SCR
Deadman Creek	Undesignated	CW, SCR
Little Canyon Creek	Undesignated	SS, CW, SCR
Ryegrass Creek	Undesignated	CW, SCR
Sailor Creek	Undesignated	CW, SCR

[1]CW – cold water, SS – salmonid spawning, PCR – primary contact recreation, SCR – secondary contact recreation, AWS – agricultural water supply, DWS – domestic water supply, SRW – special resource water

Criteria to Support Beneficial Uses

As shown in Table 12, the above-mentioned beneficial uses are protected by a set of criteria, which include *narrative* criteria for pollutants such as sediment and nutrients and *numeric* criteria for pollutants such as dissolved oxygen, pH, and turbidity (IDAPA 58.01.02.250) (Table 12).

DEQ's procedure to determine whether a water body fully supports designated and existing beneficial uses is outlined in IDAPA 58.01.02.053. The procedure relies heavily upon biological parameters and is presented in detail in the Water Body Assessment Guidance (Grafe et al. 2002). This guidance requires the use of the most complete data available to make beneficial use support status determinations.

Figure 15 provides an outline of the stream assessment process for determining support status of the beneficial uses of cold water aquatic life, salmonid spawning, and contact recreation.

2.3 Pollutant/Beneficial Use Support Status Relationships

Most of the pollutants that impair beneficial uses in streams are naturally occurring stream characteristics that have been altered by humans. For example, streams naturally contain sediment, nutrients, but when anthropogenic sources cause these to reach unnatural levels, they are considered "pollutants" and can impair the beneficial uses of a stream. The following summaries discuss the effects of each related "pollutant" or the side effect of the pollutant on aquatic life and where relevant, contact recreation.

Dissolved Oxygen

Oxygen is necessary for the survival of most aquatic organisms and essential to stream purification. Dissolved oxygen (DO) is the concentration of free (not chemically combined) molecular oxygen (a gas) dissolved in water, usually expressed in milligrams per liter (mg/L), parts per million, or percent of saturation. While air contains approximately 20.9% oxygen gas by volume, the proportion of oxygen dissolved in water is about 35%, because nitrogen (the remainder) is less soluble in water. Oxygen is considered to be moderately soluble in water. A complex set of physical conditions that include atmospheric and hydrostatic pressure, turbulence, temperature, and salinity affect the solubility.

Dissolved oxygen levels of 6 mg/L and above are considered optimal for aquatic life. When DO levels fall below 6 mg/L, organisms are stressed, and if levels fall below 3 mg/L for a prolonged period, these organisms may die; oxygen levels that remain below 1-2 mg/L for a few hours can result in large fish kills. Dissolved oxygen levels below 1 mg/L are often referred to as hypoxic; anoxic conditions refer to those situations where there is no measurable DO.

Juvenile aquatic organisms are particularly susceptible to the effects of low DO due to their high metabolism and low mobility (they are unable to seek more oxygenated water). In addition, oxygen is necessary to help decompose organic matter in the water and bottom sediments. Dissolved oxygen reflects the health or the balance of the aquatic ecosystem. Oxygen is produced during photosynthesis and consumed during plant and animal respiration and decomposition. Oxygen enters water from photosynthesis and from the atmosphere. Where water is more turbulent (e.g., riffles, cascades), the oxygen exchange is greater due to the greater surface area of water coming into contact with air. The process of oxygen entering the water is called aeration.

Water bodies with significant aquatic plant communities can have significant DO fluctuations throughout the day. Oxygen sags will typically occur once photosynthesis stops at night and respiration/decomposition processes deplete DO concentrations in the water. Oxygen will start to increase again as photosynthesis resumes with the advent of daylight. In many cases excess aquatic plants can cause supersaturation, whereby DO levels may reach unusually high levels during the daylight hours.

Temperature, flow, nutrient loading, and channel alteration all impact the amount of DO in the water. Colder waters hold more DO than warmer waters. As flows decrease, the amount of aeration typically decreases and the in-stream temperature increases, resulting in decreased DO. Channels that have been altered to increase the effectiveness of conveying water often have fewer riffles and less aeration. Thus, these systems may show depressed levels of DO in comparison to levels before the alteration. Nutrient enriched waters have a higher biochemical oxygen demand due to the amount of oxygen required for organic matter decomposition and other chemical reactions. This oxygen demand results in lower in-stream DO levels.

Sediment

Both suspended (floating in the water column) and bedload (moves along the stream bottom) sediment can have negative effects on aquatic life communities. Many fish species can tolerate elevated suspended sediment levels for short periods of time, such as during natural spring runoff, but longer durations of exposure are detrimental. Elevated suspended sediment levels can interfere with feeding behavior (difficulty finding food due to visual impairment), damage gills, reduce growth rates, and in extreme cases eventually lead to death.

Newcombe and Jensen (1996) reported the effects of suspended sediment on fish, summarizing 80 published reports on streams and estuaries. For rainbow trout, physiological stress, which includes reduced feeding rate, is evident at suspended sediment concentrations of 50 to 100 mg/L when those concentrations are maintained for 14 to 60 days. Similar effects are observed for other species, although the data sets are less reliable. Adverse effects on habitat, especially spawning and rearing habitat presumably from sediment deposition, were noted at similar concentrations of suspended sediment.
Organic suspended materials can also settle to the bottom and, due to their high carbon content, lead to low intergravel DO through decomposition.

In addition to these direct effects on the habitat and spawning success of fish, detrimental changes to food sources may also occur. Aquatic insects, which serve as a primary food source for fish, are affected by excess sedimentation. Increased sedimentation leads to a macroinvertebrate community that is adapted to burrowing, thereby making the macroinvertebrates less available to fish. Community structure, specifically diversity, of the aquatic macroinvertebrate community is diminished due to the reduction of coarse substrate habitat.

Settleable solids are defined as the volume (milliliters [ml]) or weight (mg) of material that settles out of a liter of water in one hour (Franson et al. 1998). Settleable solids may consist of large silt, sand, and organic matter. Total suspended solids (TSS) are defined as the material collected by filtration through a 0.45 µm (micrometer) filter (APHA 1995). Settleable solids and TSS both contain nutrients that are essential for aquatic plant growth. Settleable solids are not as nutrient rich as the smaller TSS, but they do affect river depth and substrate nutrient availability for macrophytes. In low flow situations, settleable solids can accumulate on a stream bottom, thus decreasing water depth. This increases the area of substrate that is exposed to light, facilitating additional macrophyte growth.

Nutrients

While nutrients are a natural component of the aquatic ecosystem, natural cycles can be disrupted by increased nutrient inputs from anthropogenic activities. The excess nutrients result in accelerated plant growth and can result in a eutrophic or enriched system.

The first step in identifying a water body's response to nutrient flux is to define which of the critical nutrients is limiting. A limiting nutrient is one that normally is in short supply relative to biological needs. The relative quantity affects the rate of production of aquatic biomass. Either phosphorus or nitrogen may be the limiting factor for algal growth, although phosphorous is most commonly the limiting nutrient in Idaho waters. Ecologically speaking, a resource is considered limiting if the addition of that resource increases growth.

Total phosphorus (TP) is the measurement of all forms of phosphorus in a water sample, including all inorganic and organic particulate and soluble forms. In freshwater systems, typically greater than 90% of the TP present occurs in organic forms as cellular constituents in the biota or adsorbed to particulate materials (Wetzel 1983). The remainder of phosphorus is mainly soluble orthophosphate, a more biologically available form of phosphorus than TP that consequently leads to a more rapid growth of algae. In impaired systems, a larger percentage of the TP fraction is comprised of orthophosphate. The relative amount of each form measured can provide information on the potential for algal growth within the system.

Nitrogen may be a limiting factor at certain times if there is substantial depletion of nitrogen in sediments due to uptake by rooted macrophyte beds. In systems dominated by blue-green algae, nitrogen is not a limiting nutrient due to the algal ability to fix nitrogen at the water/air interface.

Total nitrogen to TP ratios greater than seven are indicative of a phosphorus-limited system while those ratios less than seven are indicative of a nitrogen-limited system. Only biologically available forms of the nutrients are used in the ratios because these are the forms that are used by the immediate aquatic community.

Nutrients primarily cycle between the water column and sediment through nutrient spiraling. Aquatic plants rapidly assimilate dissolved nutrients, particularly orthophosphate. If sufficient nutrients are available in either the sediments or the water column, aquatic plants will store an abundance of such nutrients in excess of the plants' actual needs, a chemical phenomenon known as luxury consumption. When a plant dies, the tissue decays in the water column and the nutrients stored within the plant biomass are either restored to the water column or the detritus becomes incorporated into the river sediment. As a result of this process, nutrients (including orthophosphate) that are initially released into the water column in a dissolved form will eventually become incorporated into the river bottom sediment. Once these nutrients are incorporated into the river sediment, they are available once again for uptake by yet another life cycle of rooted aquatic macrophytes and other aquatic plants. This cycle is known as nutrient spiraling. Nutrient spiraling results in the availability of nutrients for later plant growth in higher concentrations downstream.

Sediment – Nutrient Relationship

The linkage between sediment and sediment-bound nutrients is important when dealing with nutrient enrichment problems in aquatic systems. Phosphorus is typically bound to particulate matter in aquatic systems and, thus, sediment can be a major source of phosphorus to rooted macrophytes and the water column. While most aquatic plants are able to absorb nutrients over the entire plant surface due to a thin cuticle (Denny 1980), bottom sediments serve as the primary nutrient source for most sub-stratum attached macrophytes. The USDA (1999) determined that other than harvesting and chemical treatment, the best and most efficient method of controlling growth is by reducing surface erosion and sedimentation.

Sediment acts as a nutrient sink under aerobic conditions. However, when conditions become anoxic sediments release phosphorous into the water column. Nitrogen can also be released, but the mechanism by which it happens is different. The exchange of nitrogen between sediment and the water column is for the most part a microbial process controlled by the amount of oxygen in the sediment. When conditions become anaerobic, the oxygenation of ammonia (nitrification) ceases and an abundance of ammonia is produced. This results in a reduction of nitrogen oxides (NO_x) being lost to the atmosphere.

Sediments can play an integral role in reducing the frequency and duration of phytoplankton blooms in standing waters and large rivers. In many cases there is an immediate response in phytoplankton biomass when external sources are reduced. In other cases, the response time is slower, often taking years. Nonetheless, the relationship is important and must be addressed in waters where phytoplankton is in excess.

Floating, Suspended, or Submerged Matter (Nuisance Algae)

Algae are an important part of the aquatic food chain. However, when elevated levels of algae impact beneficial uses, the algae are considered a nuisance aquatic growth. The excess growth of phytoplankton, periphyton, and/or macrophytes can adversely affect both aquatic life and recreational water uses. Algal blooms occur where adequate nutrients (nitrogen and/or phosphorus) are available to support growth. In addition to nutrient availability, flow rates, velocities, water temperatures, and penetration of sunlight in the water column all affect algae (and macrophyte) growth. Low velocity conditions allow algal concentrations to increase because physical removal by scouring and abrasion does not readily occur. Increases in temperature and sunlight penetration also result in increased algal growth. When the aforementioned conditions are appropriate and nutrient concentrations exceed the quantities needed to support normal algal growth, excessive blooms may develop.

Commonly, algae blooms appear as extensive layers or algal mats on the surface of the water. When present at excessive concentrations in the water column, blue-green algae often produce toxins that can result in skin irritation to swimmers and illness or even death in organisms ingesting the water. The toxic effect of blue-green algae is worse when an abundance of organisms die and accumulate in a central area.

Algal blooms also often create objectionable odors and coloration in water used for domestic drinking water and can produce intense coloration of both the water and shorelines as cells accumulate along the banks. In extreme cases, algal blooms can also result in impairment of agricultural water supplies due to toxicity. Water bodies with high nutrient concentrations that could potentially lead to a high level of algal growth are said to be eutrophic. The extent of the effect is dependent on both the type(s) of algae present and the size, extent, and timing of the bloom.

When algae die in low flow velocity areas, they sink slowly through the water column, eventually collecting on the bottom sediments. The biochemical processes that occur as the algae decompose remove oxygen from the surrounding water. Because most of the decomposition occurs within the lower levels of the water column, a large algal bloom can substantially deplete DO concentrations near the bottom. Low DO in these areas can lead to decreased fish habitat as fish will not frequent areas with low DO. Both living and dead (decomposing) algae can also affect the pH of the water due to the release of various acid and base compounds during respiration and photosynthesis. Additionally, low DO levels caused by decomposing organic matter can lead to changes in water chemistry and a release of sorbed phosphorus to the water column at the water/sediment interface.

Excess nutrient loading can be a water quality problem due to the direct relationship of high TP concentrations on excess algal growth within the water column, combined with the direct effect of the algal life cycle on DO and pH within aquatic systems. Therefore, the reduction of TP inputs to the system can act as a mechanism for water quality improvements, particularly in surface-water systems dominated by blue-green algae, which can acquire nitrogen directly from the atmosphere and the water column. Phosphorus management within these systems can potentially result in improvement in nutrients (phosphorus), nuisance algae, DO, and pH.

Pesticides

DDT and dieldrin have been identified as the primary pesticides of concern in C.J. Strike Reservoir. Many pesticides, including DDT and dieldrin, and their breakdown products have potential effects on reproductive, nervous, and immune systems, as well as on chemically sensitive individuals. For example, some of the most frequently detected pesticides are suspected endocrine disrupters that have potential to affect reproduction or development of aquatic organisms or wildlife by interfering with natural hormones.

Total Dissolved Gas

Total dissolved gas (TDG) concentrations are considered elevated when they exceed 110%. Beyond this level, TDG is known to have detrimental effects on aquatic life, primarily fish. High concentrations of gas dissolved in water can result in a phenomenon known as gas bubble trauma. This condition occurs when air bubbles form in the circulatory system. The severity of the effects of gas bubble trauma varies among different aquatic species and life stages within those species.

2.4 Summary and Analysis of Existing Water Quality Data

The following presents the data assessment methods used during this assessment, followed by analyses for the subwatersheds (Snake River, Snake River tributaries, and the C.J. Strike Reservoir), and comments regarding additional resource management considerations addressed by the assessment.

The amount of available data varied substantially between subwatersheds. Types of available data also ranged widely, but typically represent biological, chemical, and physical parameters. Data pertinent to the water quality issues being addressed are presented for each listed stream in this section.

Data Assessment Methods

Several primary analysis methods were used to evaluate the data for this subbasin assessment:

- Evaluation Using the DEQ-Water Body Assessment Guidance – Second Edition
- Evaluation Using Stream Bank Erosion Inventory
- Evaluations of Intermittence for Selected Streams
- Evaluation Using Bioaccumulation Factors for (t)-DDT and Dieldrin
- Evaluation Using the CE-QUAL-W2 Water Quality Model

Detailed descriptions of these methods are located in Appendices E, F, G, and H. A brief description of each method follows.

DEQ-Water Body Assessment Guidance – Second Edition

The Water Body Assessment Guidance II (WBAG) (Grafe et al. 2002) describes DEQ's methods used to consistently evaluate data and determine the beneficial use support status of Idaho water bodies. The WBAG is not used to determine pollutant-specific impairment. Rather, it utilizes a multi-index approach to determine overall stream support status. The methodology addresses many reporting requirements of state and federal rules, regulations, and policies. For the most part, DEQ Beneficial Use Reconnaissance Program (BURP) data is used in the assessment. However, where available, other data is integrated into the assessment process. Figure 15 (above) shows the details of the assessment process.

An assessment entails analyzing and integrating multiple types of water body data, such as biological, physical/chemical, and landscape data to address multiple objectives. The objectives include the following:

1. Determine beneficial use support status of the water body (i.e., fully supporting versus not fully supporting).
2. Determine biological integrity using biological information or other measures.
3. Compile descriptive information about the water body and data used in the assessment.

The multi-metric index approach measures biological, physiochemical, and physical habitat conditions within a stream. The indexes include several characteristics to gauge overall stream health. Three primary indexes are used, which include the Stream Macroinvertebrate Index (SMI), the Stream Fish Index (SFI) and the Stream Habitat Index (SHI). The SMI is a direct measure of cold water aquatic life health. The SFI is also a direct measure of cold water aquatic life health, but is specific to fish populations. The SHI is used to measure in-stream habitat suitability, although some of the measurements used to generate the SHI are linked to the riparian area.

Stream Bank Erosion Inventory

The stream bank inventory was used to estimate background and existing stream bank and channel erosion. The inventory follows methods outlined in the proceedings from the National Resource Conservation Service (NRCS) Channel Evaluation Workshop (1983). The NRCS stream bank erosion inventory is a field-based method that measures bank and channel characteristics—such as stability, length of eroding banks, and depth of eroding banks—to calculate a long-term lateral recession rate. The recession rate is expressed in terms of the feet of stream bank lost due to erosion per year (ft/year). The lateral recession rate can then be combined with the volumetric mass of the bank material and the length of the segment to determine the sediment load from the stream banks.

The stream bank erosion inventories are linked to bank stability, which is used as a surrogate for in-stream particle size distributions. Previous TMDLs (DEQ 2001a, 2001b, 2003) have established a linkage between 80% stream bank stability and less than 30% fine substrate material in riffles. This linkage allows for the restoration of beneficial uses to be assessed based on bank stability (i.e. streams with >80% bank stability will likely support cold water aquatic life beneficial uses). Of course, this linkage is based on sediment related use impairment only. If factors other than excess sediment are impairing uses, this method will not detect them, and they must be addressed elsewhere.

For the King Hill-C.J. Strike TMDL, DEQ staff calculated the stream bank erosion rates of stream types where banks are expected to be greater than 80% stable and the particle size distribution in riffles is expected to contain less than 30% fines (particles <6.0 mm in diameter). These erosion rates were then used as reference rates for similar morphological channel types on the §303(d) listed streams where banks are eroding and fine materials exceed 30% in riffles. The reference rates become the benchmark for the impaired stream and, thus, the basis of load reductions.

Evaluations of Intermittence for Selected Streams

The state of Idaho defines an intermittent stream as one that has a period of zero flow for at least one week during most years or that has a 7Q2 (a measure of the annual minimum 7-day mean stream flow, based on a 2 year low) hydrologically based flow of less than 0.10 cfs (IDAPA 58.01.02.003.51). If a stream contains naturally perennial pools with significant aquatic life, it is not considered intermittent.

Using this definition as guidance, DEQ identified eight §303(d) listed intermittent stream segments, as shown in Table 14. (Appendix F provides a detailed analysis showing why each stream segment was determined to be intermittent.) The implication of this determination is that TMDLs with the intent of restoring local (in the intermittent segment) beneficial uses will not be performed for these stream segments because water is not present during the critical loading period (typically the growing season) or when aquatic life beneficial uses are expected to be fully supported based on life cycles (middle to late summer months). IDAPA 58.01.02.070.07 states that water quality standards shall only apply to intermittent waters during optimum flow periods sufficient to support the beneficial uses for which the water body has been designated. The optimum flow for contact recreation is equal to or greater than 5.0 cfs. The optimum flow for aquatic life is equal to or greater than 1.0 cfs. However, TMDLs developed for downstream, perennial segments may apply to these segments because of their potential to contribute pollutants when water is flowing. For example, if an intermittent segment is typified by unstable, eroding banks due to anthropogenic causes, the load created during flow periods would be subject to a TMDL.

Table 14. §303(d) listed intermittent stream segments in the King Hill-C.J. Strike Subbasin.

Water Body	§303(d) Boundary	Intermittent Segment(s)
Bennett Creek	Headwaters to Snake River	Near 3,773 feet[1] to Snake River
Ryegrass Creek	Headwaters to Cold Springs Creek	Near 3,609 feet to Cold Springs Creek
Cold Springs Creek	Ryegrass Creek to Snake River	Near 3,609 feet to near 2,821 feet
Alkali Creek	Headwaters to Snake River	Near 3,444 feet to near 2,821 feet
Little Canyon Creek	Headwaters to Snake River	Near 4,101 feet to near 2,624 feet
Browns Creek	Headwaters to Snake River	Headwaters to near Snake River
Sailor Creek	Headwaters to Snake River	Headwaters to near Snake River
Deadman Creek	Headwaters to Snake River	Headwaters to near Snake River

[1] elevation, in feet, above sea level

Bioaccumulation Factors for (t)-DDT and Dieldrin

C.J. Strike Reservoir is §303(d) listed for pesticides. However, no water column pesticide or pesticide related data (such as fish tissue data) are available for the transition and lacustrine zones of the reservoir. Fish tissue data are, however, available at Loveridge Bridge, which falls within riverine zone of the reservoir. Using the Loveridge Bridge data as a surrogate for the entire reservoir, Bioaccumulation Factors (BAF) were developed for (t)-DDT and dieldrin to estimate the water column concentrations of total DDT and dieldrin in C.J. Strike Reservoir. The water column concentrations were then compared to the applicable criteria in the *Idaho Water Quality Standards and Wastewater Treatment Requirements* for DDT and dieldrin to determine beneficial use support status for domestic water supply and cold water aquatic life. Bioaccumulation Factors were developed following the guidance outlined in *"Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health"* (EPA 2000). Appendix G outlines in more detail the process and calculations used to develop the final estimated concentration.

CE-QUAL-W2 Water Quality Model

CE-QUAL-W2, Version. 3.1 is a two-dimensional, longitudinal/vertical, hydrodynamic water quality model that has been applied to rivers, lakes, reservoirs and estuaries throughout the world. The model assumes lateral homogeneity, making it best suited for long and narrow waterbodies exhibiting strong longitudinal and vertical water quality gradients, such as C.J. Strike Reservoir.

Setup of the model requires geometric, bathymetric, and meteorologic data and boundary condition information. The boundary condition information includes flow, water temperature and water quality data. All of this information is available from a variety of sources. Model output capabilities include hydrodynamic functions, such as water surface elevations, velocities, and temperatures. Water quality constituents include parameters, such as dissolved oxygen and nutrients (among many others).

The CE-QUAL-W2 model was to set up and applied to C.J. Strike Reservoir by Idaho Power Company in cooperation with HDR Engineering, HyQual, and Scott Wells of Portland State University. Appendix H summarizes the use of the model as it applies to C.J Strike Reservoir.

Snake River Data Analysis

The Snake River is a complex system that has been studied by numerous entities along its length. The following data analysis pertains to the river segment between King Hill (River Mile 546.3) and Indian Cove (River Mile 525.3). More specifically, the analysis pertains to sediment and nutrients and their related water quality parameters. Unfortunately, it is not possible at this time to perform a fully comprehensive study pertaining to all known issues within the river.

Flow Characteristics / Selection of a Baseline Flow

The USGS has collected flow data from the Snake River near King Hill since 1910. These data represent the most comprehensive data within the §303(d) listed segment and are the flow data used by nearly every researcher investigating the Snake River. Figure 16 shows the annual mean flow for each year during the period of record (POR) at King Hill.

However, in evaluating the water quality data for this assessment, the POR flow data were not used (for reasons that will shortly be described), but they do give some insight into the historic flow regimes. Is should be noted that the construction of several dams on the Snake River above King Hill has change the look of the hydrograph.

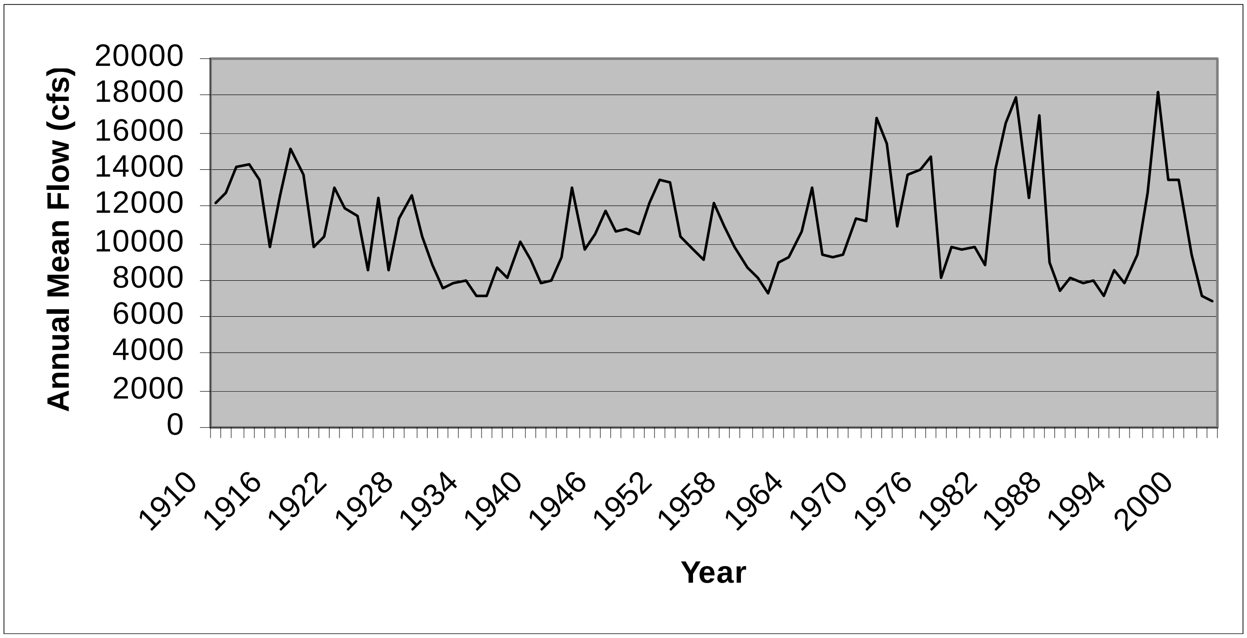

Figure 16. Snake River at King Hill, 1910 – 2002 Annual Mean Flow

The entirety of the 1910-2002 flow data do not represent current flow conditions in the Snake River at King Hill, but the 1986-2002 flow data do—for a couple of reasons: 1) based on the POR flow data, these years capture the full range of flows expected to occur (high through low), and 2) extensive water quality data are available during those years, whereas such data are not available for the years prior to 1986. These years best represent "typical" flow conditions in the Snake River at King Hill, and determining this flow is an important step in determining the baseline flow for development of the TMDL.

Figure 17 shows the annual mean flows for 1986-2002 as compared to the mean flow for the entire period. Figure 18 shows the monthly averages for 1986-2002.

The monthly flow figure illustrates that the river reaches a base flow in October, after water has been removed for irrigation purposes along the system, which occurs primarily in July, August, and September. The increase in April, May, and June is primarily due to spring runoff flows.

Using the 1986-2002 flow data as a starting point, the flow years were further evaluated to determine a narrower span of years that are representative of flow conditions in the river. While the 1986-2002 data are representative of a long-term unmanaged (no dams) flow regime, it is typically not necessary to evaluate such a long period. Figure 16 (above) shows that the years 1997-2002 also capture the full range of flows expected to occur (high through low). The water quality data are also fairly robust during this period. **Thus, the 1997-2002 flows were chosen to represent the baseline flow conditions for TMDL development.** Figure 19 shows the 1997-2002 flow data compared to the monthly means and the mean of the monthly means.

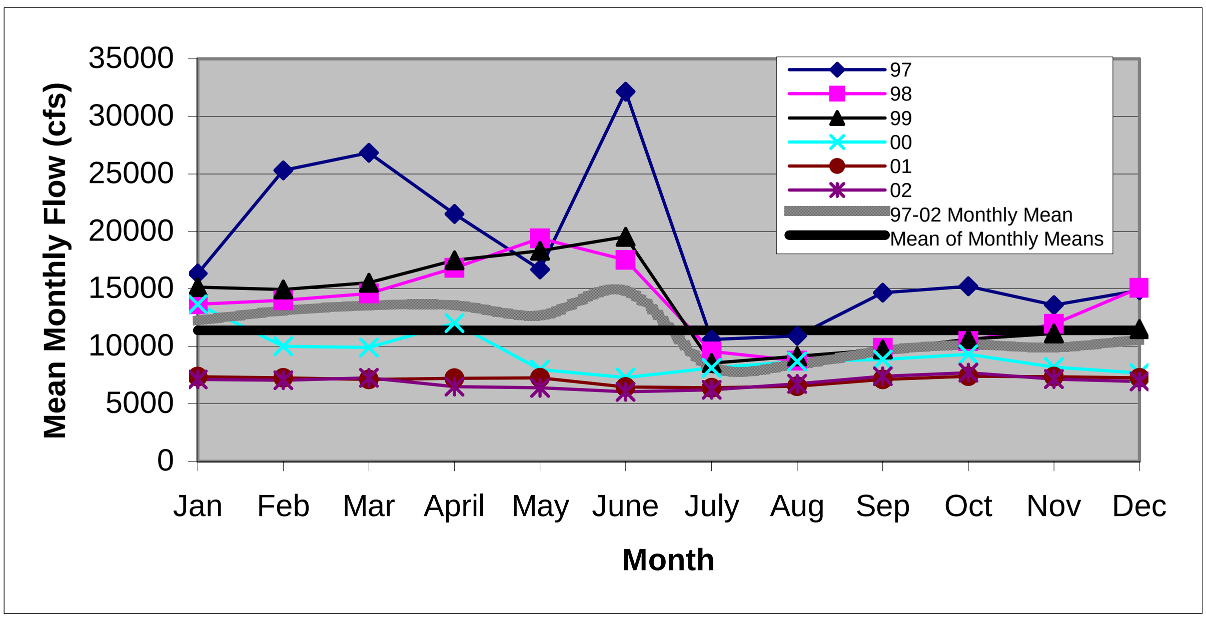

Figure 19. Mean monthly flows at King Hill for the period 1997-2002

As illustrated in Figure 19, the mean of the monthly mean flows is slightly over 11,000 cfs. The actual value is 11,407 cfs. This flow was used as the baseline for TMDL development. That is, **the King Hill sediment and nutrient load allocations presented in Chapter 5 are based on a flow of 11,407 cfs**. Based on the use of 1997-2002 flow data, a flow of 11,407 cfs is likely to occur relatively frequently by comparison to the highest flows (1997) and the lowest flows (2002) making it an appropriate flow for establishing load targets.

Water Chemistry Data

This section describes and analyzes the chemical and biological data for the Snake River between King Hill and Indian Cove. While Indian Cove is often not considered part of C.J. Strike Reservoir, velocity analysis performed by Idaho Power Company and DEQ shows that during full pool the riverine portion of C.J Strike Reservoir extends past Loveridge Bridge up to Indian Cove. Based on this analysis, Indian Cove serves as the downstream end of the Snake River segment for the purposes of assessing Snake River water quality data. The analysis showing the velocity data can be found in more detail in the C.J. Strike Reservoir water quality assessment to follow.

Figure 20 shows the locations of King Hill and Indian Cove sampling stations within the King Hill-C.J Strike watershed. Idaho Power Company and the USGS have sampled extensively at King Hill. DEQ has also sampled at King Hill, but on a less extensive basis. At Indian Cove, Idaho Power Company collected most of the data, although in recent years DEQ has collected data at King Hill. For purposes of the water quality analysis, data from all three entities were used.

Sediment Loading Analysis

In determining whether excess sediment is impairing aquatic life beneficial uses in a water body, a thorough analysis should consider both water column and substrate sediment (sediment on the river bottom) characteristics. This is especially the case if spawning is a beneficial use.

However, in systems as large as the Snake River, the analysis of substrate sediment conditions is difficult to perform and often cost prohibitive. For those reasons, very little quantitative sediment composition data exists within the listed reach. Upstream of the listed segment, near Crystal Springs (~RM 599), the sediments were characterized by Falter and Burris (1994). While the length of the study segment was limited, the authors found that fine, organic-rich surficial sediment depths ranged from 0.68 meters to 0.23 meters in depth. These excess depths of fine, organic rich sediment were found to be very influential in the growth of nuisance macrophytes. This concept is discussed further in the forthcoming biological analysis.

Recognizing that the ability to fully assess substrate sediments in the Snake River is limited, the evaluation of sediment conditions as they relate to cold water aquatic life support status is initially based on water column sediment. While salmonid (trout) spawning in the Snake River is not a designated use, it has not been conclusively determined that it is not an existing use. Thus, water column sediment is evaluated initially with the intent of further evaluating substrate sediment conditions when the chance arises.

Water Column Sediment Targets

As was shown in Table 12, the standard for sediment is narrative. The standard says "*sediment shall not exceed quantities specified in general surface water quality criteria (IDAPA 58.01.02.250 or 252) or, in the absence of specific sediment criteria, quantities which impair designated beneficial uses*." However, no specific sediment criteria exist for the Snake River between King Hill and Indian Cove, so two-tiered durational surrogate targets to the narrative standard were used instead.

Surrogates can be defined as alternative, numeric measures to narrative water quality standards. The surrogate targets are specifically designed to be protective of the designated aquatic life beneficial use (cold water aquatic life) and the potential existing salmonid spawning use. The targets were first developed as part of the Lower Boise River sediment TMDL (DEQ 1999) and are based on the extensive work of Newcombe and Jensen (1996). Newcombe and Jensen evaluated 80 published and adequately documented reports on fish response to suspended sediment concentration (SSC) in streams. The result of their work was several species and age specific dose-response matrices showing the expected effects of SSC on different species and ages of fish over different durations of exposure. For example, Newcombe and Jensen determined that adult salmonids could withstand an SSC of 20 mg/L for two weeks without experiencing major physiological stress. However, if the exposure duration were to increase to four months, major physiological stress would be noted.

Following this concept, the two-tiered durational targets shown below were developed. The targets are designed to account for both chronic and acute exposure to excess water column sediment.

- **a geometric mean of 50 mg/L suspended sediment for no longer than 60 consecutive days**
- **a geometric mean of 80 mg/L suspended sediment for no longer than 14 consecutive days**

The targets shown above are expressed in terms of suspended sediment concentration. SSC is a protective (of aquatic life) measure of water column sediment because the laboratory analysis for SSC has the finite ability to capture sand size and smaller particles in the water column. Particles of this size can be particularly dangerous to fish when present in excess.

In addition to employing the above-mentioned SSC targets, the analysis of water column sediment conditions in the Snake River between King Hill and Indian Cove also considers turbidity conditions. As shown in Table 12, the state of Idaho has a numeric water quality standard for turbidity for the protection of aquatic life. The standard says turbidity levels shall be "*less than 50 NTU (nephelometric turbidity unit) above background for any given sample or less than 25 NTU for more than 10 consecutive days (below any applicable mixing zone set by DEQ).*

- **less than 50 NTU above background for any given sample**
- **less than 25 NTU for more than 10 consecutive days**

Analysis of Suspended Sediment Concentration (SSC) Data

Suspended sediment concentration data have been collected by the USGS at King Hill since 1974. Data were typically collected monthly and are available from 1974-2002. These data are ideal for determining the SSC boundary condition to the King Hill–Indian Cove segment of the Snake River. Initially, the entire data set (1974-2002) is used to generally characterize the levels and determine seasonal variability. From there, the 1997-2002 data are evaluated against the SSC targets to determine whether the Snake River at King Hill is meeting the targets. Figures 21 and 22 show the 1974-2002 SSC data, based on all seasons (Figure 21), and the growing season (Figure 22). The growing season typically corresponds with the irrigation season, which runs from March through October. This is the time of year when elevated levels of sediment can traditionally be noticed in surface waters that are near agricultural land uses (such as the Snake River). For this reason, the growing season data are evaluated separately to determine if there is any seasonal variability.

Figure 21 shows that SSC in the Snake River at Kings Hill largely remains below 50 mg/L except in extremely high flow years, such as 1986 and 1997. While excursions above 50 mg/L do occur, they appear to be somewhat flow related. The mean SSC over the 1974-2002 period is 24 mg/L.

A comparison of Figures 21 and 22 illustrate that there is little difference in SSC concentration between the growing season and all seasons. The growing season mean SSC between 1974 and 2002 is 25 mg/L, the non-growing season SSC is 22 mg/L, and the mean of all data is 24 mg/L. These differences in concentration are negligible, indicating that there is no seasonal variability in SSC at King Hill.

Recognizing that there is no seasonal variability in SSC at King Hill, the 1997-2002 data from all seasons were evaluated against the SSC targets discussed above. Again, the 1997-2002 data were chosen because those years represent the full range of flows (high through low) expected to occur within the King Hill to Indian Cove reach. The durational nature of the targets makes a true comparison to the targets impossible because SSC data were not collected daily. To account for this data gap it is assumed that the concentration between sampling days remains static unless there is an excursion that can be explained by an acute event, such as the 1997 flood. Figure 23 shows the 1997-2002 SSC data at King Hill. The data show that concentrations remain well below 50 mg/L. The concentration of 144 mg/L that occurred on June 23, 1997, was due to events related to the 1997 flood and does not represent normal SSC conditions in the river. Based on 1997-2002 data, the mean SSC at King Hill is 18 mg/L. This level is below the targets of 50 and 80 mg/L. Thus, suspended sediment concentrations in the Snake River at King Hill do not exceed the targets.

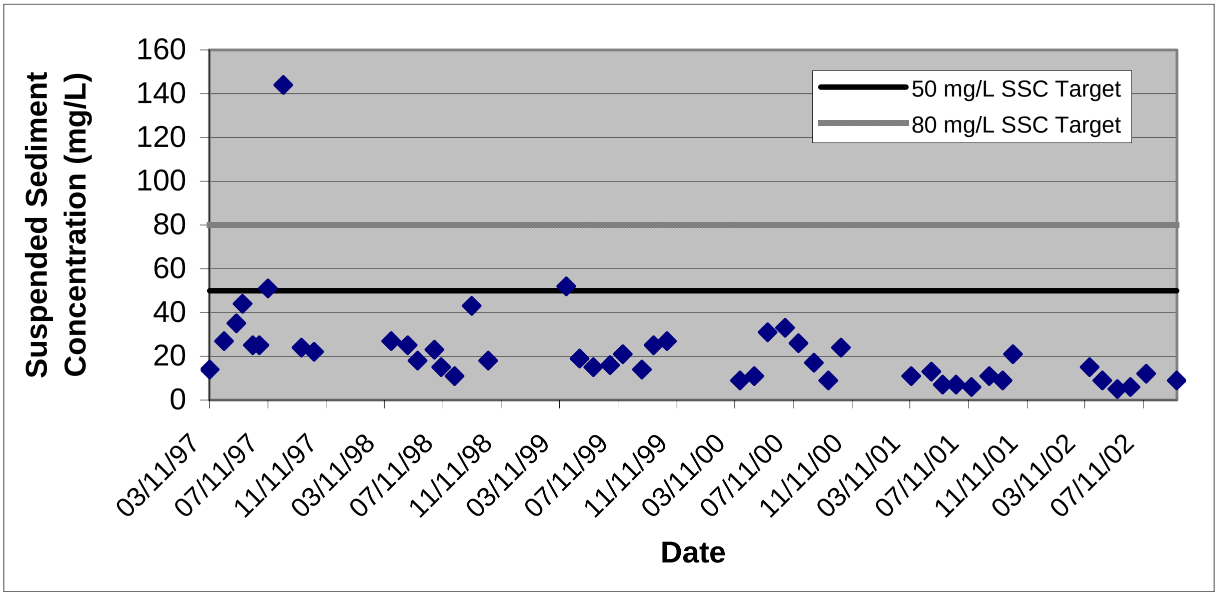

Figure 23. SSC concentrations in the Snake River at King Hill, 1997-2002 data, all seasons.

The Department of Environmental Quality (DEQ) has collected monthly SSC data at King Hill and Indian Cove since April 2003. These data are used to determine whether there is a net increase in SSC between the two sites, and, if so, whether SSC exceeds the water quality targets.

Unfortunately, the DEQ data represent the only available SSC data with which a comparison between King Hill and Indian Cove can be made. Because the tributary concentrations between King Hill and Indian Cove are typically below 10 mg/L and there are no other major sources of sediment to the river, the DEQ data likely represent the typical change in SSC between King Hill and Indian Cove. Figure 24 shows the change in SSC concentration between King Hill and Indian Cove. Based on the mean of these data, the net gain in SSC between King Hill and Indian Cove is 3 mg/L. The mean at King Hill is 22 mg/L, relatively consistent with the USGS data, while the mean at Indian Cove is 25 mg/L. Not shown on Figure 24 is the mean concentration in the river just below the city of Glenns Ferry, which was also 22 mg/L. This indicates that the SSC contributions from King Hill and Little Canyon Creeks, two of the largest volume tributaries in the basin, have no measurable change on river concentration.

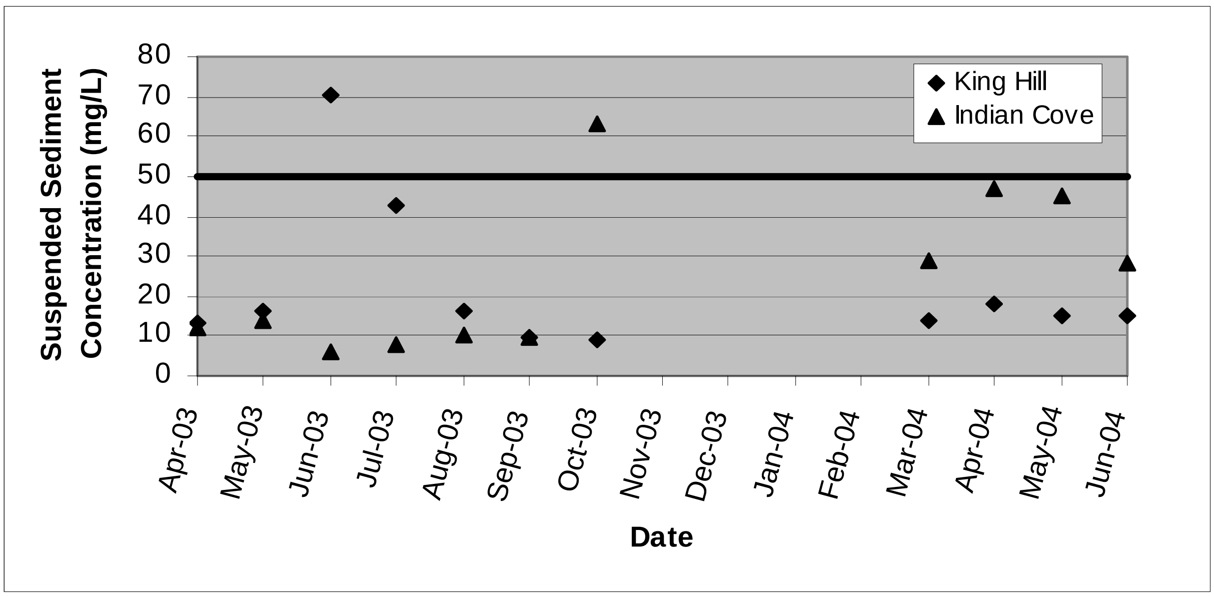

Figure 24. Comparison of SSC at King Hill to Indian Cove, 2003-2004 data, all seasons.

Figure 24 and the narrative above show that SSC between King Hill and Indian Cove does not increase substantially. The figure also suggests that concentrations do not exceed the durational targets of 50 mg/L for 60 consecutive days and 80 mg/L for 14 consecutive days. The target of 80 mg/L is never exceeded. The target of 50 mg/L was exceeded at King Hill in June 2003 and at Indian Cove in October 2003, but the duration does not appear to ever exceed 60 days. Based on these analyses, SSC in the Snake River between King Hill and Indian Cove is typically below the water quality targets. As such, SSC does not appear to be impairing the designated use of cold water aquatic life or the potentially existing use of salmonid spawning.

Analysis of Turbidity Data

Before beginning the analysis of the turbidity data, it should be noted that turbidity is not as desirable as SSC in terms of measuring water column sediment as it relates to aquatic life health. While turbidity is accepted as a surrogate to the state's narrative sediment standards (EPA 1999), it must be used with some level of caution or in conjunction with another sediment surrogate.

The reason for using caution is, in part, based on the laboratory methods by which turbidity is measured. Turbidity is expressed as the ratio of the amount of light transmitted through a sample of water to the amount of light scattered by debris in the sample. However, since the debris is nearly always composed of both organic (algae) and inorganic (sediment) material, the turbidity measurement takes into account material that is not readily harmful to aquatic life. In fact, it is possible to see elevated turbidity without any sediment in the water at all, such as is the case when the sample of water contains a significant amount of debris (that scatters light) and very little or no sediment. With that said, low turbidity levels typically also indicate low sediment levels.

Idaho Power Company has collected turbidity data at King Hill and Indian Cove since 1991. The data were collected monthly or bi-monthly and are available from 1991-1999 and 2002-early 2003. Turbidity data were not continuously collected during the years 1999-2001. As a result of this data gap, the data are evaluated based on 1995-1998 and 2002-early 2003.

Using data from the entire POR (1991-1999 and 2002-early 2003) at King Hill, the mean turbidity for all seasons is 13 NTU. The growing season mean turbidity is 14 NTU, while the non-growing season mean turbidity is 12 NTU. These means suggest that there is essentially no seasonal variability in turbidity. Thus, the data will be further evaluated on an annual basis.

Figures 25 and 26 show the turbidity levels at King Hill and Indian Cove for the years 1995-1998 and 2002-early 2003. As compared to the turbidity standard of *not to exceed 25 NTU for more than 10 consecutive days*, 11% (13 of 119) of the values exceed at King Hill while 7% (8 of 119) exceed at Indian Cove. The mean turbidity at King Hill is 15 NTU, while the mean turbidity at Indian Cove is 14 mg/L. The median turbidities at King Hill and Indian Cove are both 10 mg/L, which may actually be a better representation of the data since the values are not normally distributed.

Since the data were not collected for 10 consecutive days, a true comparison to the durational standard is again not possible. However, the means suggest that levels are typically below 25 NTU at both King Hill and Indian Cove.

Figures 27 and 28 show the change in turbidity between King Hill and Indian Cove. These figures are not effective in evaluating the data on a duration basis, but offer a better view of the data as they compare to 25 NTU and 50 NTU above background. As the standards relate to this analysis, the "background" condition is considered the concentration at King Hill. Thus, the change in turbidity between King Hill and Indian Cove should be less than 25 and 50 NTU.

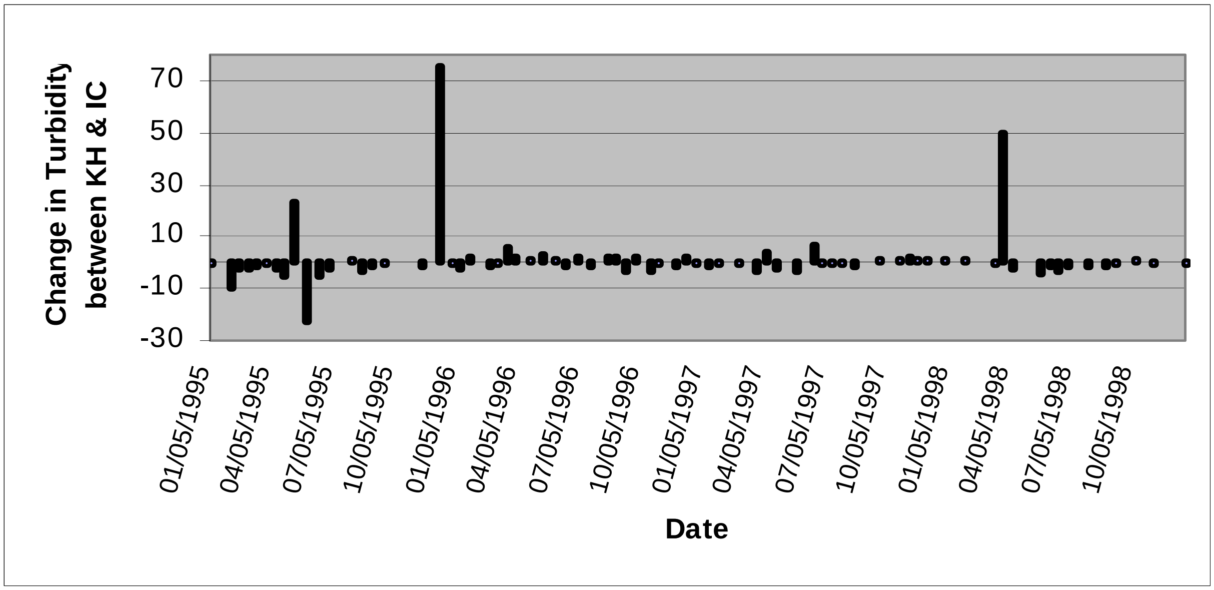

Figure 27. Change in turbidity between King Hill (KH) and Indian Cove (IC) for the years 1995-1998

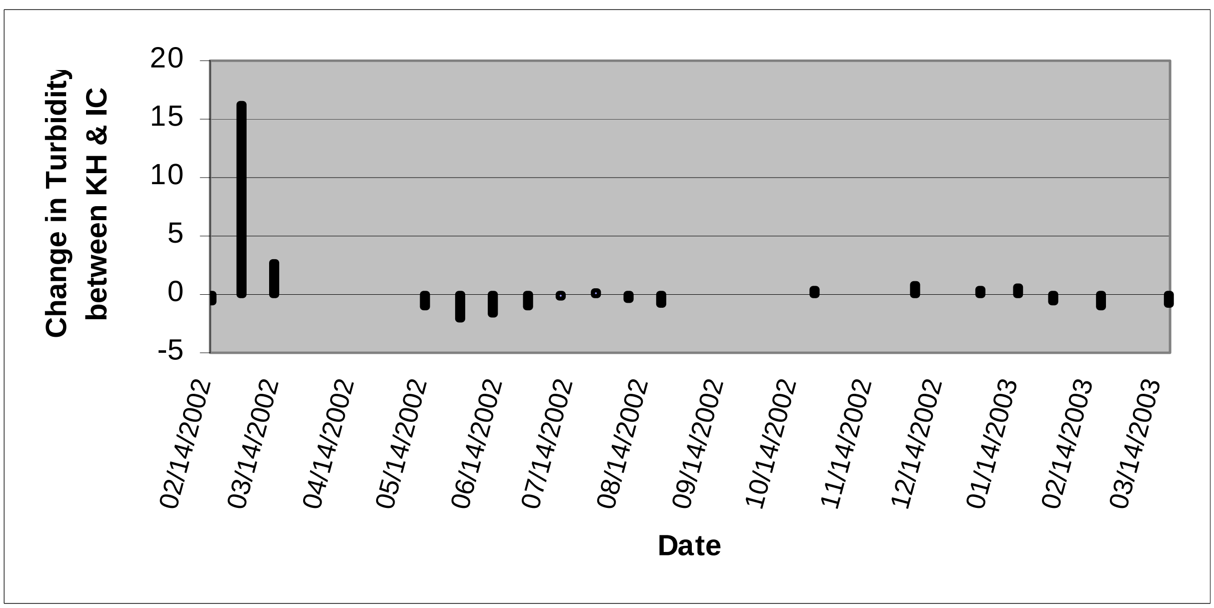

Figure 28. Change in turbidity between King Hill (KH) and Indian Cove (IC) for the years 2002-early 2003

Figures 27 and 28 show that the increase in turbidity between King Hill and Indian Cove is nearly always less than 25 NTU. Excursions above 25 and 50 NTU occurred in December 1995 and March 1998, but these increases are rare. Figures 27 and 28 are also effective in further showing that turbidity levels fluctuate very little between King Hill and Indian Cove. The mean change in turbidity between the two locations is an increase of 0.85 NTU.

Based on these analyses, turbidity levels in the Snake River between King Hill and Indian Cove are typically below the water quality standards. As such, turbidity does not appear to be impairing the designated use of cold water aquatic life or the potentially existing use of salmonid spawning.

Substrate Sediment Considerations/Macrophytes

While the SSC and turbidity data show that water column sediment is not impairing cold water aquatic life and salmonid spawning, there is an indication by Falter and Burris (1994) and a general agreement by the King Hill-C.J. Strike Reservoir Watershed Advisory Group (WAG) that there is excess sediment in the river bottom. The impetus for these findings is the resultant mass of aquatic plants that get their nutrients from the river bottom sediments. In recent years, the macrophytes have impaired recreation and aesthetics, primarily by impeding navigation. Falter and Burris (1994) found that macrophytic biomass in the river was strongly correlated to sediment total phosphorus levels, and that sediment total phosphorus levels were high. This is not surprising given the findings of other authors such as Carignan and Kalff (1980) and Barko and Smart (1981), who found that aquatic macrophytes predominantly grow with the substrate sediment as the primary source of nutrients. The authors went on to find that in the case of phosphorus, 90-100% of the uptake can be derived from root transport.

The excess amount of fine substrate sediment on the river bottom is the decisive factor in the production of excess macrophytes in the Mid-Snake River (Falter and Burris 1994). In recent years (2001-2004), the macrophytic biomass in the river has been very high. Idaho Power Company has tracked the number of truckloads of macrophytes removed from the trash racks at Upper Salmon Falls dam (~RM 580) since 1991. The data show that the number of truckloads removed in 2001-2003 are 419, 669, and 759, respectively. These numbers are notably higher than the average number of truckloads removed per year since 1991, which is 361. Correspondingly, 2001-2003 are three of the lowest flow years on record for the Snake River (see Figure 17). The lack of flushing flows to scour the substrate sediment in 2001-2003 and into 2004 appears to be one of the primary reasons aquatic macrophyte biomass is elevating. This can be further confirmed by the findings of Falter and Burris (1994) in which they noted that macrophyte biomass tends to decline when water velocities increase.

Appendix I shows the macrophyte beds on the Snake River between King Hill and Indian Cove during September 2004. According to some members of the King Hill-C.J. Strike WAG, the macrophytes were worse in 2004 than in recent memory. The macrophytes species identified by Falter and Burris (1994) in the Snake River were primarily *Potamogeton crispus, Potamogeton pectinatus,* and *Ceratophyllum demersum*. Epiphytic filamentous green algae were also identified. The species were primarily *Cladophora* and

Hydrodictyon. In terms of succession, the rooted macrophytes, epiphytes, and some non-rooted macrophytes were co-dominant through August; epiphytes were dominant through October.

The overabundance of sediment bound aquatic macrophytes in the Snake River appears to be in part due to an excess of organically rich fine sediment. While some level of aquatic macrophytes is very important to the river ecosystem, the macrophytes become a nuisance when they become excessive. As noted above, positive relationships have been developed between macrophytic biomass in the river and sediment total phosphorus levels. However, there exists very little information regarding the quantity of organic rich sediment required to generate excessive levels. As a result of this critical data gap, DEQ recommends initiating substrate sampling in the years immediately following high flow years. The expectation is that in the year(s) following high velocity flushing flows, the macrophytic biomass levels will be significantly reduced. Figure 29 shows a comparison of truckloads of macrophytes removed at Upper Salmon Falls dam to the average annual flow at King Hill. Note that in the years following the 1997 high flows, the macrophytes were significantly decreased, but in recent years when flows have been very low, the macrophytes were significantly increased.

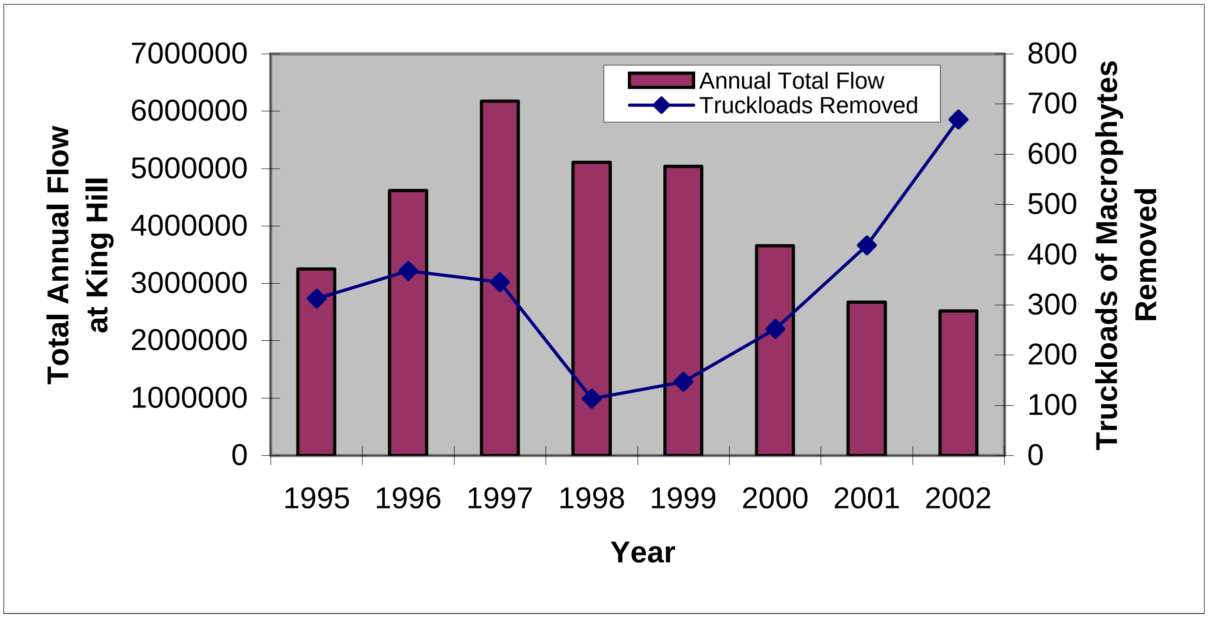

Figure 29. Number of truckloads of macrophytes removed from Upper Salmon Falls dam as compared to average annual flow at King Hill.

The intent of the additional sampling would be to characterize a "baseline" condition for which a potential substrate sediment TMDL can be developed. The intent of the TMDL would be to identify the amount of substrate sediment the river can assimilate before nuisance macrophytes begin to accumulate. Sediment levels beyond that assimilative capacity would be considered inappropriate. The details of this sampling will not be drafted as part of this assessment, but rather will be part of the TMDL implementation plan to follow.

Summary of Sediment Analysis

While the SSC and turbidity data show that water column sediment is not impairing cold water aquatic life and salmonid spawning, the overabundance of sediment-bound macrophytes indicates that substrate sediment may be in excess. As a result, DEQ does not recommend removing sediment from the §303(d) list. Rather, DEQ recommends preparing a water column sediment TMDL based on existing conditions to help manage any additional sediment that might be discharged to the river. The TMDL will not require reductions, but it will serve as a benchmark above which water column sediment levels in the river should not exceed. Chapter 5 outlines the TMDL in more detail.

Nutrient Loading Analysis

In determining whether excess nutrients are impairing aquatic life and contact recreation beneficial uses in a water body, the analysis of information must consider the effects of excess nutrients on nutrient related water quality parameters, such as dissolved oxygen levels, chlorophyll-a concentrations and aquatic plant masses. These secondary measures are considered numeric surrogates to the narrative water quality standard for nutrients. Rarely do excess nutrients themselves pose a threat to beneficial uses; it is the secondary effects that create impairment.

Defining the Limiting Nutrient

The goal when identifying a waters response to nutrient flux is to define which of the primary nutrients (nitrogen or phosphorus) is limiting the growth of aquatic plants. The nutrient that is in the shortest supply is typically defined as the limiting nutrient because its relative quantity can affect the rate of production of aquatic biomass. In fresh water, phosphorus tends to be the limiting nutrient. A general rule, often applied to determine which nutrient is limiting, is the nitrogen:phosphorus (N:P) ratio. If N:P is greater than ten, the limiting agent is typically phosphorus, and excessive algal growth will usually not occur if phosphorus is reduced appropriately. Conversely, if the N:P is less than 10, the limiting nutrient is typically nitrogen. It should also be noted that, in some systems, neither nutrient is limiting. This often occurs when the water is extremely enriched and both nutrients are in excess. Figure 30 shows the TN:TP ratios at King Hill on a monthly average basis for the years 1995-2002. To increase the robustness of this analysis, only paired data were used. That is, the samples used to calculate the TN and the TP sample were collected on the same day at the same time.

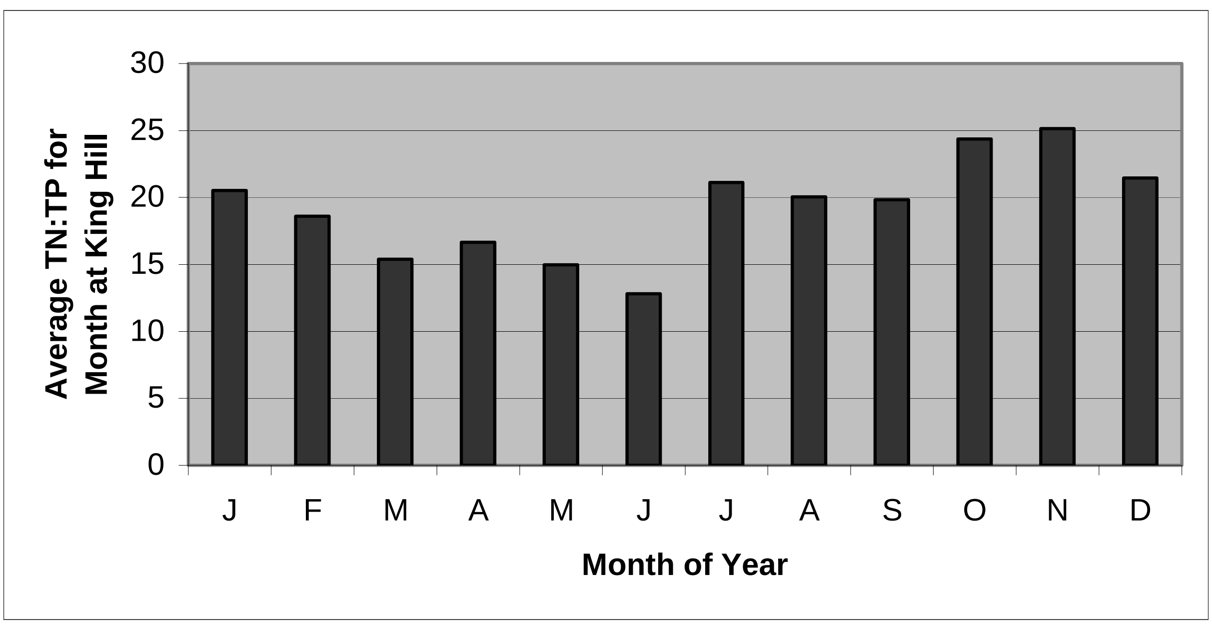

Figure 30. 1995-2002 monthly average TN:TP ratios at King Hill.

The data presented in Figure 30 shows that the TN:TP ratio exceeds 10 at all times of year thereby indicating that the Snake River is phosphorus limited. As such, the assessment of nutrients in the Snake River and any potential nutrient TMDL will be based on total phosphorus.

It is widely recognized that ortho-phosphate (OP) represents the readily bio-available fraction of total phosphorus. For this reason, it may seem to make sense to base phosphorus TMDL targets on ortho-phosphate rather than TP. However, ortho-phosphate is not a conservative constituent in terms of nutrient cycling through river and streams. Ortho-phosphate concentrations can change dramatically in a short distance or time due to growth or die-off of algae variations in dissolved oxygen concentrations. Ortho-phosphate can also convert between forms under favorable water column conditions and may not always be an accurate representation of the phosphorus available for biological consumption.

Total Phosphorus Target

As shown in Table 12, the standard for nutrients is narrative. The standard says, *"surface waters shall be free from excess nutrients that can cause visible slime growths or other nuisance aquatic growths impairing designated beneficial uses."* Since the level of TP that will help preclude the development of nuisance aquatic growth in the Snake River between King Hill and Indian Cove is unknown, DEQ evaluated and chose to use the water column TP TMDL target of 0.075 mg/L TP developed for the adjacent upstream segment of the Snake River (DEQ 1997). As it applies to the Snake River between King Hill and Indian Cove, this target is applied as follows:

- **less than or equal to 0.075 mg/L (75 µg/L) total phosphorus at all locations in the river**

The rationale and justification for applying this TP target to the King Hill and Indian Cove segment of the Snake River is two tiered:

1. The derivation of the original target, as part of the Middle Snake River TMDL (DEQ 1997), accounted for EPA's (1986) recommended standards for free-flowing waters bodies (0.100 mg/L), lake tributaries (0.050 mg/L), and lakes and reservoirs (0.025 mg/L). It was concluded by the Middle Snake River Technical Advisory Committee (TAC) that the Middle Snake River was characterized by all three water types. As such, the TAC felt that 0.075 mg/L TP was a reasonable, preliminary target for water column TP. To help substantiate this target, the Middle Snake River TMDL also employed the RBM10 water quality model to verify whether the target of 0.075 mg/L TP was achievable (due to TMDL implementation) and protective of beneficial uses. The final model simulation showed that within ten years of TMDL implementation, proposed nutrient reductions should reach a concentration of 0.0728 mg/L TP at Gridley Bridge, which serves as the compliance point for the Middle Snake River TMDL. Thus, the target was achievable.

   Another aspect of the 0.075 mg/L TP target derived from the RBM10 model simulations was that plant biomass (macrophytes and epiphytes) responded somewhat to TP reductions. The simulations showed that after implementation of the targets, the plant biomass was reduced by 20-30%, thereby reducing the impacts of excess aquatic vegetation on beneficial uses in the Middle Snake River.

2. For the analysis of nutrient data (TP) as it relates to beneficial use support status, EPA (2000d) guidance suggests identifying three concentration ranges based on a frequency of distribution as a starting point for determining reference conditions, at risk conditions, and impaired condition. This analysis was performed as part of the Snake River-Hells Canyon TMDL (DEQ 2004) for three reaches of the Snake River: river miles greater than 600, river miles 400-600, and river miles 409-335. In order to ensure representative ranges, and minimize the potential that outliers in the data would create a bias, the lowest and highest measured values (5%) were eliminated from consideration. The assessment was accomplished using the data distributed between the 5th and 95th percentiles. This data distribution was then divided evenly into three categories, with the 35th percentile concentration defining the threshold below which reference conditions would be defined, and the 65th percentile defining the threshold above which impairment was projected to occur. The concentration range described between the 35th and the 65th percentiles was recommended as a definition of allowable conditions, with lower values tending toward better water quality conditions and higher concentration values being defined as more at risk for impairment. Table 15 shows the results of the analysis for river miles 400-600, the segment in which the King Hill (546) to Indian Cove (525) reach is located.

Table 15. Distribution of all available total phosphorus data within Snake River miles 400-600

Snake River Reach	Data Range	35th Percentile	65th Percentile
Snake River between (RM 400 and 600)	0.022 to 0.411	0.065 mg/L	0.077 mg/L

Using the general guidance from the EPA (2000d), the 35th percentile data from the section of the Snake River between river miles 400 and 600 was used to identify concentration values appropriate to reference conditions for the Snake River system. Within this data set, total phosphorus concentrations equal to or less than 0.065 mg/L would represent high quality “reference” conditions. Applying the 65th percentile concentration value as the threshold concentration above which impairment would be projected to occur would establish an upper concentration limit of 0.077 mg/L for total phosphorus. This correlates well with the proposed target of 0.075 mg/L for the support of designated beneficial uses.

Analysis of Total Phosphorus Data

Total phosphorus concentration data have been collected at King Hill by the USGS and at King Hill and Indian Cove by Idaho Power Company since 1967 and 1992, respectively. Data were typically collected on a monthly or bi-monthly basis. While the USGS data are more robust in terms of the years represented, the Idaho Power Company data are used for the TP analysis because, as opposed to the USGS data, they were collected at multiple locations along the segment. Using the Idaho Power Company data ensures better precision in terms of King Hill and Indian Cove data comparability. As with the SSC analysis, 1997-

2002 data are the years for which the analysis is focused. These years were chosen because they represent the variance in flows and concentrations expected to occur over the long-term, and the data that were collected during these years is more robust than previous years.

Figure 31 shows the annual mean and growing season mean TP concentrations at King Hill for the 1997-2002 POR. As illustrated by the similarity in the values, there appears to be very little seasonal variability in concentrations. The annual mean TP concentration is 0.084 mg/L while the growing season mean TP concentration is 0.088 mg/L. Since there is nominal seasonal variability, the 1997-2002 data from all seasons are used in further analysis and are the basis for evaluating current conditions against the TP target discussed above.

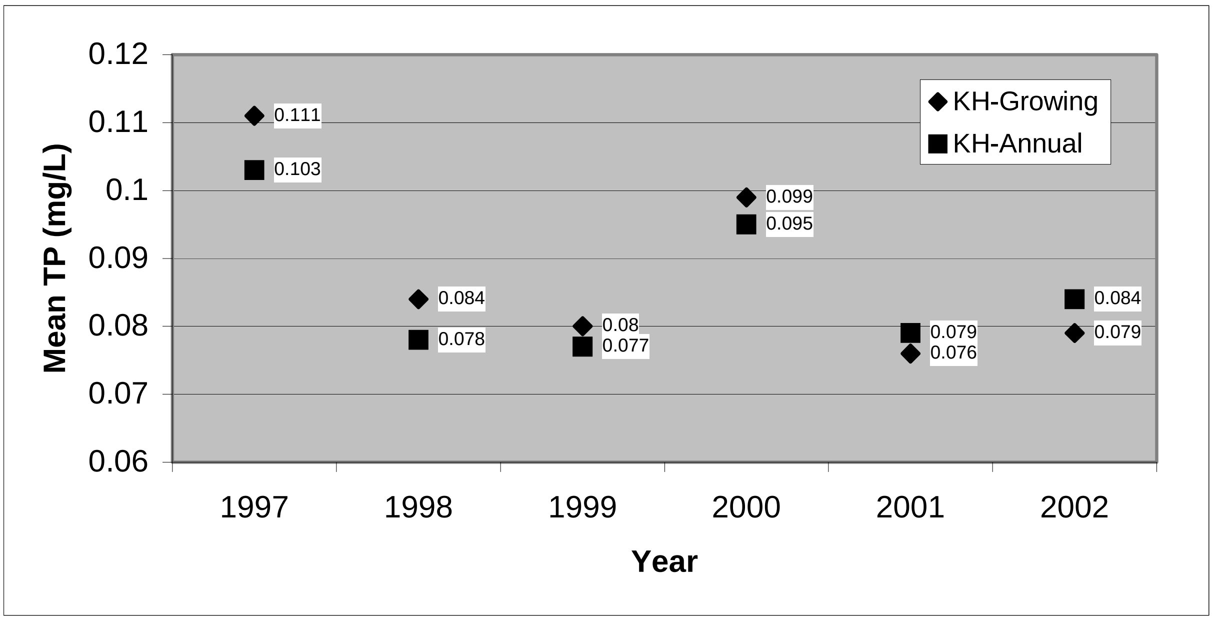

Figure 31. Annual mean and growing season TP concentrations at King Hill, 1997-2002 data.

Figure 32 shows the mean monthly TP concentrations by year at King Hill as compared to the 0.075 mg/L target. Figure 32 shows the mean monthly TP concentration by month. The data shown in figure 32 show that the mean monthly TP concentrations are slightly above or slightly below the target, depending on the year. The yearly variation is likely due to the annual differences in flows and the availability of biomass to consume the phosphorus. Significant excursions above the target occurred in March and April 1997 (flood year) and in June 1998, but these are anomalies and do not represent normal conditions. Figure 33 shows that on a monthly basis over the POR the concentrations are nearly always above the target. Only in October and November do concentrations fall below the target.

Figures 31-33 show that under current conditions, TP concentrations at King Hill exceed the target concentration of 0.075 mg/L. Using the data for all seasons, the calculated mean concentration at King Hill is 0.084 mg/L. This is the concentration that will be used as the current boundary condition for this assessment. As such, the target is exceeded and reductions are is necessary from the upstream segment of the Snake River to meet the target concentration at King Hill. In terms of concentration, this is quite a small reduction. However, the load associated with the concentration is somewhat larger. The load reduction associated with the concentration reduction is discussed in Chapter 5. It should be noted that while a TMDL is necessary, the Upper Snake Rock TMDL established TP target of 0.075 mg/L. The intent of the Upper Snake Rock TMDL is to meet 0.075 mg/L TP at King Hill.

As mentioned above, Idaho Power Company has collected water quality data at King Hill and Indian Cove. Monitoring at Indian Cove was discontinued in 2003, but monitoring continues on a voluntary basis at King Hill. The data from 1997-2002 are used to determine whether there is a net increase in TP concentration between the two monitoring sites. King Hill serves as the upstream boundary condition, while Indian Cove serves as the downstream compliance point. However, the expectation is that the Snake River must meet the 0.075 m/L target of at all locations between the two sites.

Figure 34 shows the annual mean TP concentrations at King Hill and Indian Cove. The data show that in most years the concentration at Indian Cove is nearly identical or slightly lower than King Hill. The year 2001 is the only exception. Figure 35 shows the mean monthly comparisons. As with the annual comparison, the monthly comparisons show that concentrations at Indian Cove are nearly always lower than King Hill. Using the data for all seasons, the calculated mean concentration at Indian Cove is 0.083 mg/L, further suggesting there is a slight decrease in concentration between the two sites.

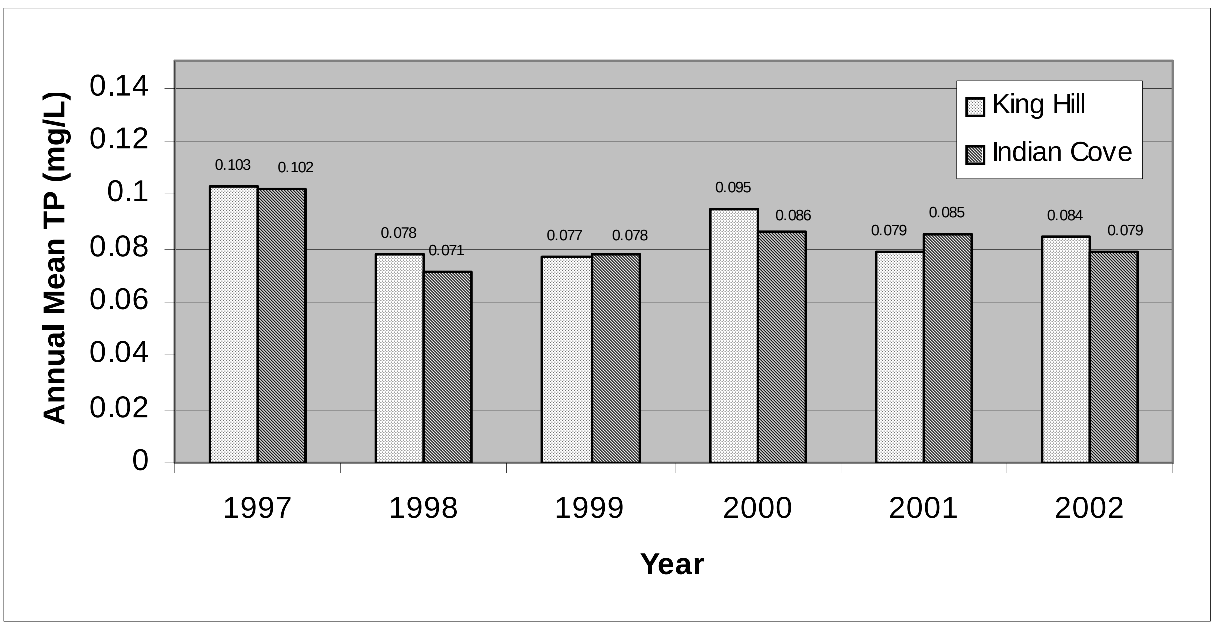

Figure 34. Annual mean TP concentrations in the Snake River at King Hill and Indian Cove, 1997-2002 data.

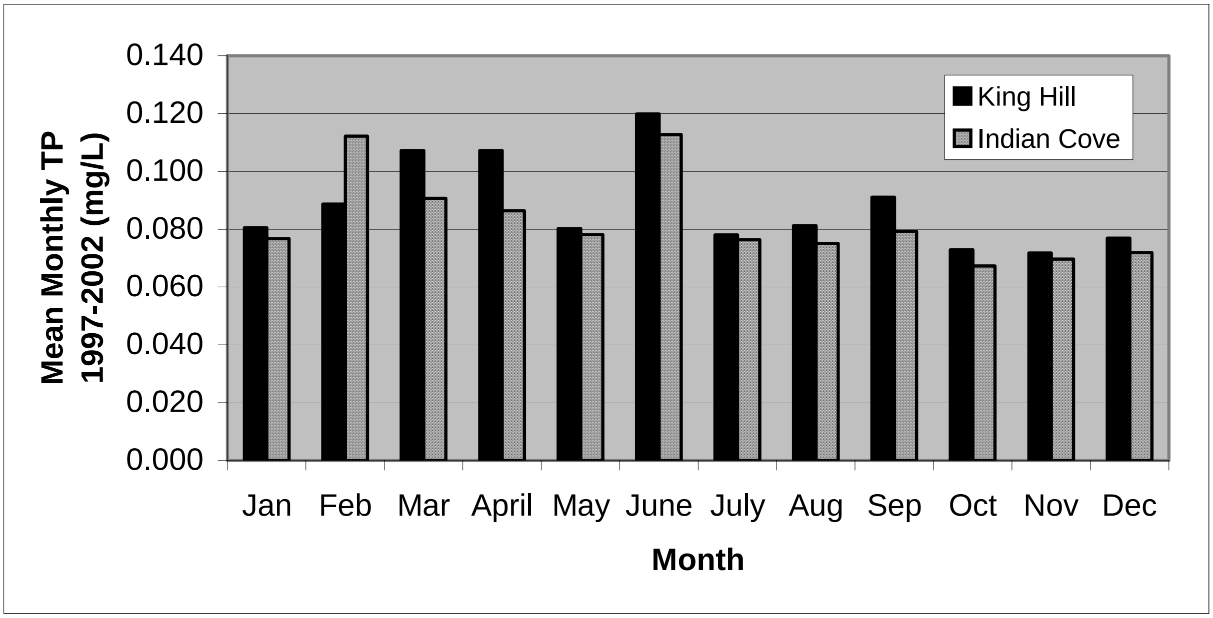

Figure 35. Mean monthly TP concentrations in the Snake River at King Hill and Indian Cove, 1997-2002 data.

Table 16 summarizes the current TP concentrations in the river at King Hill and Indian Cove as well as the current conditions as compared to the 0.075 mg/L target. Total phosphorus reductions are necessary at King Hill in order to meet the target.

Table 16. Summary of TP concentrations at King Hill and Indian Cove

River Location	Current TP Concentration (based on 1997-2002) data	TP Target
King Hill	0.084 mg/L	0.075 mg/L
Indian Cove	0.083 mg/L	0.075 mg/L

Figures 34 and 35 show that in most years TP concentrations in the water column decrease between King Hill and Indian Cove. An evaluation of the algal growth dynamics and the surface water TP sources between the two locations reveals that this phenomenon is not unexpected. Figure 36 shows annual mean TP concentrations at King Hill and Indian Cove as compared to the mean annual chlorophyll-a concentration at each site. Chlorophyll-a is a measure of algal biomass. The figure shows that in any given year the chlorophyll-a concentrations increase between King Hill and Indian Cove whereas the TP concentrations decrease. This dynamic likely occurs because the rate of TP loading between King Hill and Indian Cove does not exceed the rate at which algae and other aquatic plants consume the phosphorus.

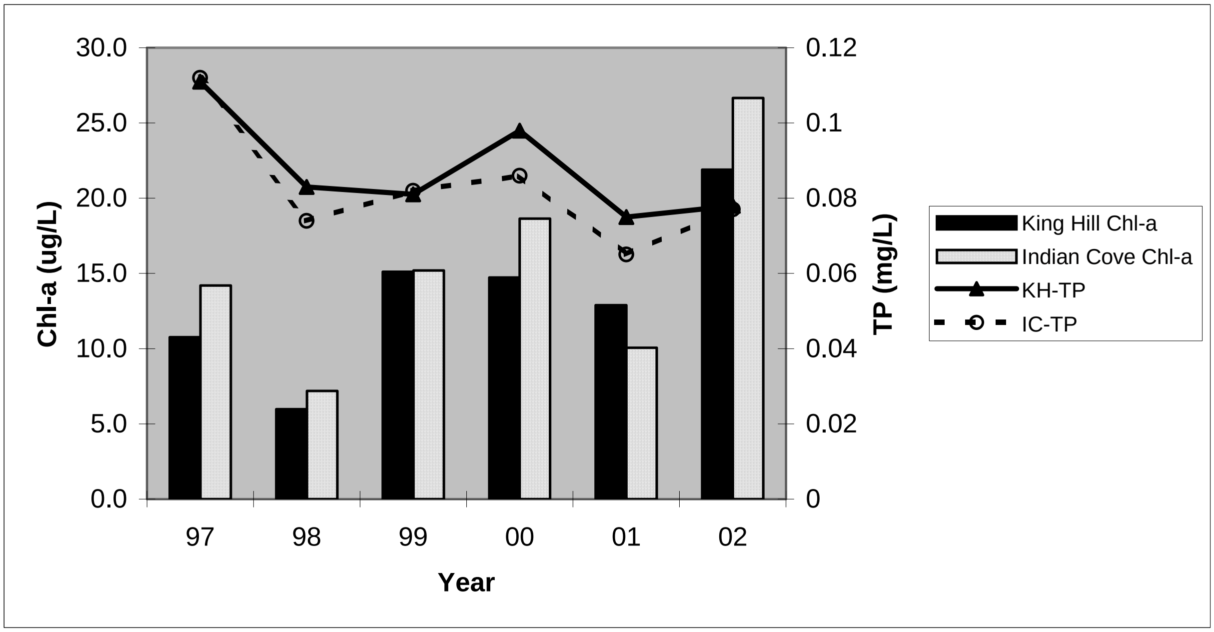

Figure 36. Annual mean TP concentrations at King Hill and Indian Cove as compared to the mean annual chlorophyll-a concentrations.

The “current TP concentrations” column in Table 16 and the data shown in Figure 36 suggest that TP loading between King Hill and Indian Cove is miniscule, is balanced by the consumption of the nutrients by algae, or a combination of both. It is likely a combination of both. To further investigate source loading between King Hill and Indian Cove, the loading potentials of King Hill, Little Canyon, Alkali, Cold Springs, and Bennett Creeks (the only tributary sources in the river segment) as well as the Glenns Ferry wastewater treatment plant (WWTP) were evaluated.

Figure 37 shows a very conservative estimate of the current TP loads from King Hill, Little Canyon, Alkali, Cold Springs, and Bennett Creeks as compared to the load in the Snake River (assuming the 0.075 target is met) and the resultant mixed concentration due to the sum of the tributary loads. The estimate is conservative because it is based on an in-river flow of 4717 cfs, which is the lowest minimum of the daily mean flows at King Hill. The figure shows that at no time does the in-river concentration increase beyond 0.075 mg/L. This is the case because of dilution. There simply is not a large enough TP load in the tributaries to make a noticeable difference in the river even using very conservative assumptions. Based on a river load of 1,910 lbs/day, the actual increase in river load due to the tributaries (total of 48 lbs/day) is approximately 2.5%. Using a typical (and more realistic) load of 4,619 lbs/day, the approximate increase would fall to 1.0% of the river load.

Stream Name	Measured Mean Flow	TP Conc.*	TP Load in Trib (lbs/day)	Snake River Flow**	Snake River Load (.075 mg/L)	Mixed Conc. in River
Cold Springs Creek	6.1	0.127	4.18	4717	1910.39	0.0751
Little Canyon Creek	18	0.207	20.12	4717	1910.39	0.0755
Bennett Creek	4.5	*0.207*	5.03	4717	1910.39	0.0751
Alkali Creek	0.85	*0.207*	0.95	4717	1910.39	0.0750
King Hill Creek	16	*0.207*	17.88	4717	1910.39	0.0754
*Bennett, Alkali, and King Hill Creek concentrations based on Little Canyon Creek concentration						***0.0754***
**Estimated lowest minimum of the daily mean flows for the POR at King Hill = 4717 cfs						

Figure 37. Estimated tributary TP loads as compared to in-river load and change in concentration.

The Glenns Ferry WWTP is authorized to discharge to the Snake River under National Pollutant Discharge Elimination System (NPDES) number ID-002200-04. The current permit, which was issued on November 24, 2003, does not include effluent limits for total phosphorus. Additionally, the city of Glenns Ferry does not currently monitor the effluent concentrations for total phosphorus. This requirement is scheduled to begin in January 2006.

To evaluate how the Glenns Ferry WWTP total phosphorus load affects the Snake River, a site specific mass balance for the river between King Hill and the Glenns Ferry discharge point was developed. The intent of the mass balance was to determine the expected TP load in the river directly above the discharge point. The river load was then mixed with the WWTP load to determine the concentration and load increase attributable to the WWTP. Appendix J shows the mass balance spreadsheet, which illustrates that concentration and load increases in the Snake River, as a result of the WWTP discharge, are 0.0006 mg/L and 25.7 lbs/day, respectively. The percent increases above Snake River concentration and load conditions are both around 0.90%. Table 17 summarizes the results of the spreadsheet. The TP concentration in the river after the Glenns Ferry WWTP is added increases diminimusly to 0.076 mg/L.

Table 17. Increase in TP concentration and load in the Snake River due to the Glenns Ferry WWTP

Change	Increase in the Snake River	Percent Increase
TP concentration increase due to WWTP	0.0006 mg/L	0.85%
TP load increase due to WWTP	25.7 lbs/day	0.86%

As illustrated in Figure 37, Appendix J and Table 17, the increase in TP concentration in the river as a result of the tributaries and the Glenns Ferry WWTP are negligible. Again, the reason for this negligible increase is due to the dilution factor of the Snake River. Neither the tributaries nor the WWTP increase the in-river TP concentration to a level significantly above the 0.075 mg/L target even using very conservative assumptions.

Even though the above analysis shows that TP levels in the river do not increase significantly due to the tributaries and the Glenns Ferry WWTP, load and wasteload allocations will still be developed for the sources. Since the river is currently exceeding the TP target, allocations must be established to set a baseline loading level, beyond which the sources should not exceed. The load allocations for the tributaries will be based on current conditions, as described in Figure 37. The wasteload allocation for the WWTP will be based on the plants current design capacity. The intent of the wasteload allocation will be to protect water quality in the river in the event that the facility grows beyond its current design capacity. The details of the load and wasteload allocations are outlined further in Chapter 5.

Biological and Other Surrogate Nutrient Parameters

Surrogate measures are particularly useful in determining beneficial use support status as it relates to nutrient enrichment because nutrient enrichment itself typically does not impair uses: the *side effects* of enrichment cause impairment. These side effects include elevated algae growth (chlorophyll-a), low (or extremely high) dissolved oxygen (DO) concentration, and pH shifts. Excessive aquatic plant growth (macrophytes and epiphytes) can also be enhanced by nutrient enrichment, but recent literature specific to the Snake River found that substrate bound nutrients are more of an issue than water column nutrients. The following section describes the analysis of the chlorophyll-a , DO, and pH surrogate parameters as they relate to phosphorus enrichment in the river and the water quality standards.

Chlorophyll-a

The evaluation of chlorophyll-a concentrations as they related to nutrient enrichment and contact recreation beneficial use support status often takes into account both water column (suspended) and benthic (substrate attached) chlorophyll-a. In large rivers, such as the Snake River, benthic chlorophyll-a is typically not evaluated because poor river clarity often precludes the development of benthic algae. Additionally, benthic chlorophyll-a is difficult to sample in large rivers. For this assessment, only water column chlorophyll-a was be evaluated.

Chlorophyll-a is the essential photosynthetic pigment found in aquatic plants. The amount of chlorophyll-a in suspended algae is commonly used to measure algal productivity. While chlorophyll-a concentrations vary from species to species, it remains a viable surrogate for algae biomass (Carlson, 1980, Watson et al., 1992). The EPA also suggests that chlorophyll-a is a desirable endpoint because it can usually be correlated to loading conditions (EPA, 1999). While the state of Idaho does not have a numeric criterion for chlorophyll-a, several other states and authors have developed targets based on a variety of conditions. The state of Oregon's threshold is 15 µg/L. When the Oregon threshold is exceeded in an average of three samples at a representative location, a follow-up is made to ascertain if a beneficial use is adversely impacted. The state of North Carolina has a chlorophyll-a criterion of 40 µg/L, which indicates impairment. Raschke (1993) proposed a level of 25 µg/L for surface waters used for viewing pleasure, boating, safe swimming, and fishing and also developed discoloration ratings based on corresponding concentration. Table 18 shows Raschke's (1993) discoloration ratings.

Table 18. Water discoloration linked to chlorophyll-a concentrations for waters in the southeastern United States.

Chlorophyll-a (µg/L)	Degree of Water Discoloration
Less than 10	No water discoloration
10 to 15	Some discoloration, some development of algae scums
20-30	Deep discoloration, frequent algal scum formation
Greater than 30	Very deep discoloration, intense matting of algal scums

The ranges identified above as being protective of designated beneficial uses extend from less than 10 µg/L to 40 µg/L. Using these ranges as a starting point, the downstream Snake River-Hells Canyon TMDL (DEQ 2004) further evaluated the numbers to determine concentrations protective of aesthetics, recreation, and domestic water supply. The results of the analysis yielded a chlorophyll-a target of 14 µg/L.

The allowable level of exceedance for this target is recognized as a critical factor in the support of designated beneficial uses. Frequency exceedance levels of up to 25% were found to be protective for recreational uses by Smeltzer and Heiskary (1990) and have been applied in this assessment. Given the existing data set at King Hill and Indian Cove, based on summer growing season chlorophyll-a concentrations, this 25% exceedance level, combined with the 14 µg/L mean growing season concentration target results in a nuisance threshold of 30 µg/L chlorophyll-a. The chlorophyll-a targets as they apply to the Snake River between King Hill and Indian Cove can be written as follows:

- **14 µg/L mean growing season chlorophyll-*a* concentration**
- **No greater than 25% of the data shall exceed the nuisance threshold of 30 µg/L chlorophyll-*a***

Figure 38 shows the mean growing season chlorophyll-a concentrations at King Hill and Indian Cove for the years 1997-2002. Other than 2001, the chlorophyll-a at Indian Cove is essentially equal to or higher than King Hill. Table 19 shows the same data in table format. Interestingly, chlorophyll-a concentrations are very low at both locations in 1998, the year after the 1997 flood.

As the concentrations compare to the mean growing season target (14 µg/L), the target is exceeded at King Hill in 1999, 2000, and 2002 and at Indian Cove in 1997, 1999, 2000, and 2002. To account for the disparity in years exceeded and year not exceeded the mean concentration for all growing season during 1997-2002 POR was calculated. The values are 15 µg/L at King Hill and 17 µg/L at Indian Cove. Both are greater than the 14 µg/L target, indicating that chlorophyll-a is in excess and excessive aquatic plants are impairing contact recreational beneficial uses.

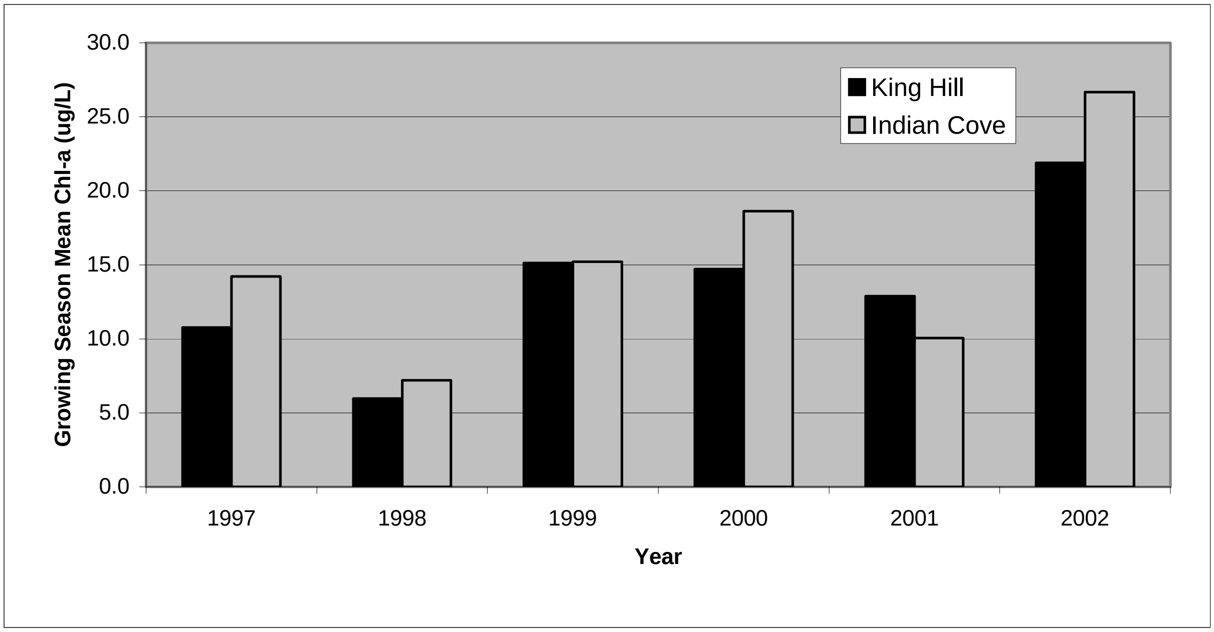

Figure 38. Mean growing season chlorophyll-a concentrations at King Hill and Indian Cove, 1997-2002 data.

Table 19. Mean growing season chlorophyll-a concentrations at King Hill and Indian Cove, 1997-2002 data.

Year	King Hill - Growing Season Mean Chl-a (µg/L)	Indian Cove - Growing Season Mean Chl-a (µg/L)
1997	10.8	14.2
1998	6.0	7.2
1999	15.1	15.2
2000	14.7	18.6
2001	12.9	10.1
2002	21.9	26.7

As the chlorophyll-a concentrations compare to the nuisance threshold target (less than 25% should exceed 30 µg/L), the target is not exceeded at King Hill or Indian Cove. Using the 1997-2002 data, 9.2% and 11.1% of the concentrations exceed 30 µg/L, respectively. This indicates that while the concentrations do reach levels that cause some discoloration (as indicated by the growing season means above), they rarely reach levels that cause deep discoloration and frequent algal scums.

Dissolved Oxygen

Dissolved oxygen concentrations can be a direct indicator of nuisance aquatic growth in that as aquatic algal biomass increases, the amount of nighttime respiration increases as well. As respiration increases, the volume of oxygen removed from the water increases. Thus, DO concentrations decrease. In excessive algae growth situations, the result is often low DO concentrations that stress or even kill sensitive species of fish and macroinvertebrates.

Opposite of DO decreases (sags) that occur during the night due to respiration, it is also common to observe DO over-saturation during the day. This occurs when excess algae photosynthesize and create elevated amounts of oxygen that over saturate the water column. This phenomenon is not as critical as oxygen sags in terms of tracking aquatic life support, but it is an indicator of aquatic plant enrichment.

As shown in Table 12, the state has numeric criteria for DO in surface waters. For lotic waters (flowing water such as rivers and streams), the standard says DO shall be "*greater than 6.0 mg/L at all times*." There are exemptions for some parts of lakes and reservoirs, which will be discussed later in the reservoir assessment.

Figure 39 shows the DO concentrations at King Hill and Indian Cove for all times of the year between 1997 and 2002. Concentrations never fall below 6.0 mg/L despite a clear abundance of macrophytes and epiphytes. The mean concentration at King Hill is 10.12 mg/L, while the mean concentration at Indian Cove is 10.50 mg/L. These concentrations equate to about 100% oxygen saturation. The slight increase in mean DO concentration appears to be due to the in-river increase between King Hill and Indian Cove in the years 2000-2002.

Unfortunately, the data shown in Figure 39 were all collected during the daytime hours. As mentioned above, DO sags are expected to occur during the night when respiration is occurring. These data do not allow for the investigation of nighttime sags. In an attempt to partially fill the data gap, King Hill samples collected before 9:00 a.m. were evaluated separately to determine the change in concentration. DO is expected to be at its lowest at dawn because algae have been respiring throughout the night. At 9:00 a.m. the sun has only been up for 2.5-3 hours. If DO levels were very low at dawn, they should still be relatively low at 9:00 A.M.

The King Hill DO data collected before 9:00 a.m. reveals a concentration of 9.09 mg/L. This value is 1.03 mg/L lower than the mean concentration for all data (10.12 mg/L) indicating that DO does sag at night. However, since the concentration is still well above 6.0 mg/L, DO sags significantly below the criteria probably do not occur.

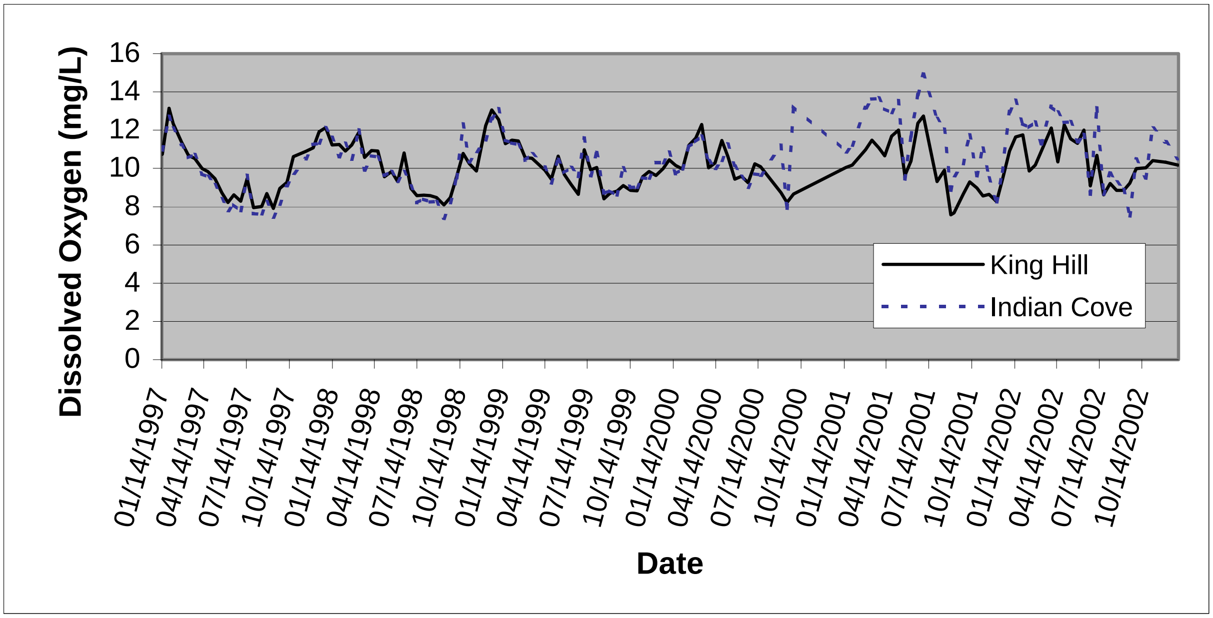

Figure 39. Dissolved oxygen concentrations at King Hill and Indian Cove, 1997-2002 data.

Figure 40 shows the DO concentration at King Hill and Indian Cove, separated by the growing season (March-October) and the non-growing season. As expected, DO concentrations are slightly lower during the growing season. Again, this is likely due to the respiratory activities of excess macrophytes and epiphytes at night. During the non-growing season, when aquatic plants are less abundant, the DO levels increase and stabilize.

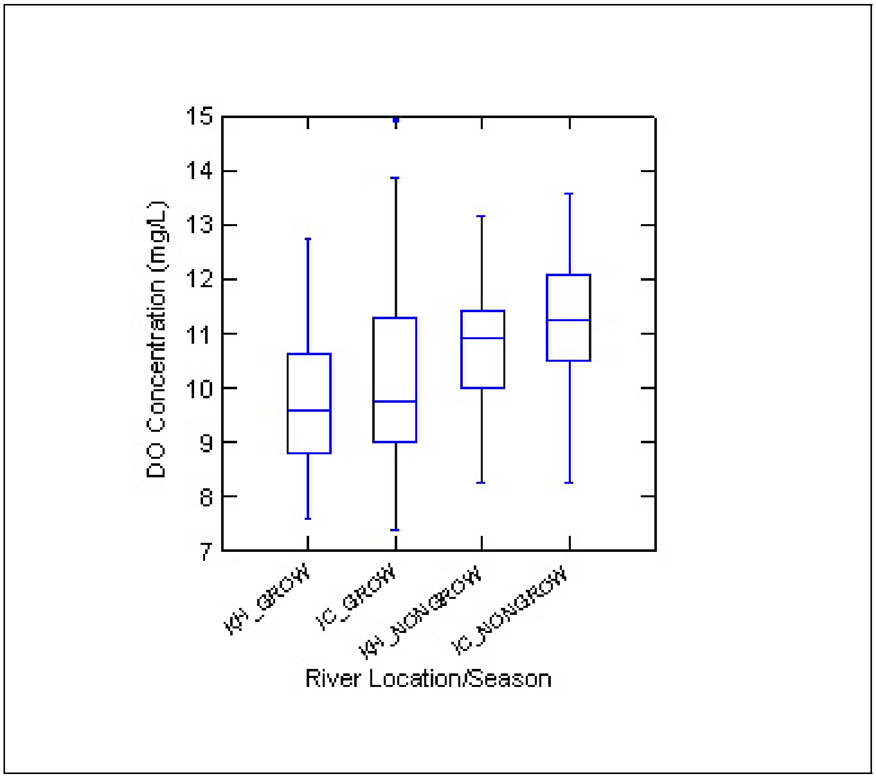

Figure 40. Growing and non-growing season DO concentrations at King Hill and Indian Cove, 1997-2002 data.

pH

pH is a measure of the concentration of hydrogen ions in water. Waters that display a very high or very low ionic concentration typically have restricted flora and fauna, in both species richness and abundance (Allan 1995). The effects of excess nutrients on pH levels in lotic waters such as the Snake River are in part a function of the nutrient-algae relationship and ultimately a function of the algal biomass in the system. When algal biomass conditions become very excessive, the water body typically experiences an increased volume of carbon dioxide in the water at night due to plant respiration. This increase in carbon dioxide beyond the normal range disrupts the stream's ability to buffer itself. When carbon dioxide levels increase, the pH typically drops. If the river has the ability to buffer itself, pH shifts may not be noticeable. However, the data should be evaluated to determine the rivers buffering ability.

As was shown in Table 12, the state has numeric criteria for pH in surface waters. For lotic waters (flowing water such as rivers and streams), the standard says *"hydrogen ion concentration (pH) values shall be within the range of 6.5 to 9.0."*

Figures 41 and 42 shows the range of pH values at King Hill and Indian Cove for the years 1997-2002. Figure 42 shows that the median, 70th and 90th quartiles at King Hill and Indian Cove are essentially the same. The median values are 8.27 and 8.26, respectively. The pH at

Indian Cove briefly exceeded nine in 2002 (Figure 40), but the exceedence does not appear to be chronic and do not represent typical conditions. Only 2.2% of the data for the 1997-2002 period exceed nine. These exceedances are likely due to the very low flow conditions that occurred in 2002.

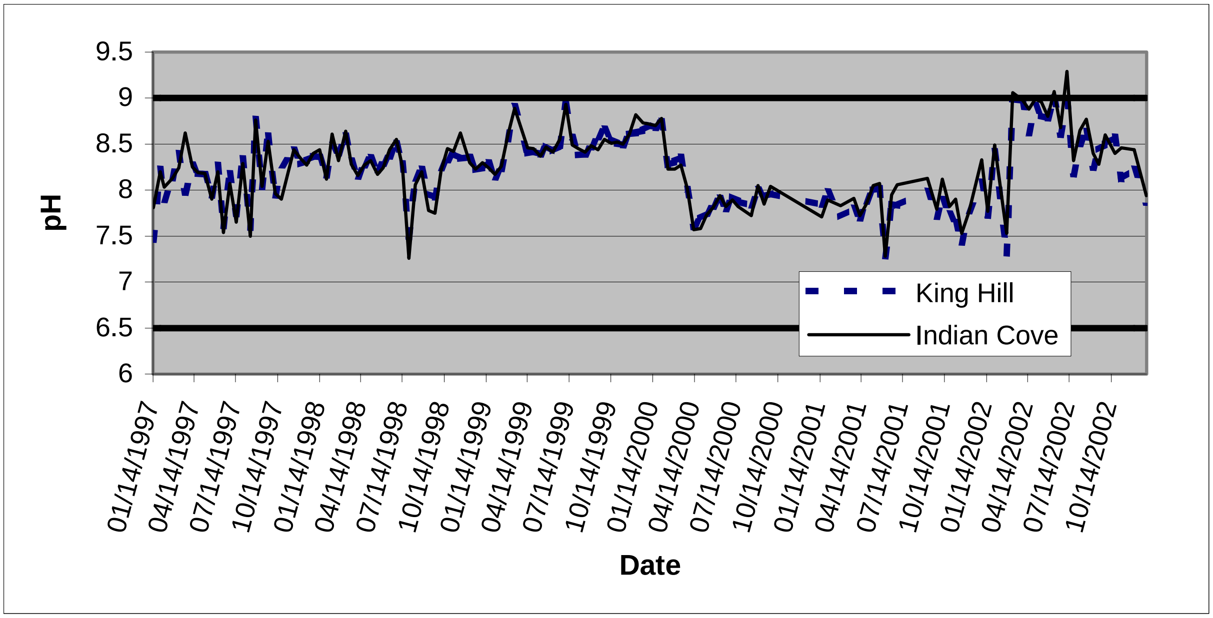

Figure 41. pH values at King Hill and Indian Cove, 1997-2002 all data.

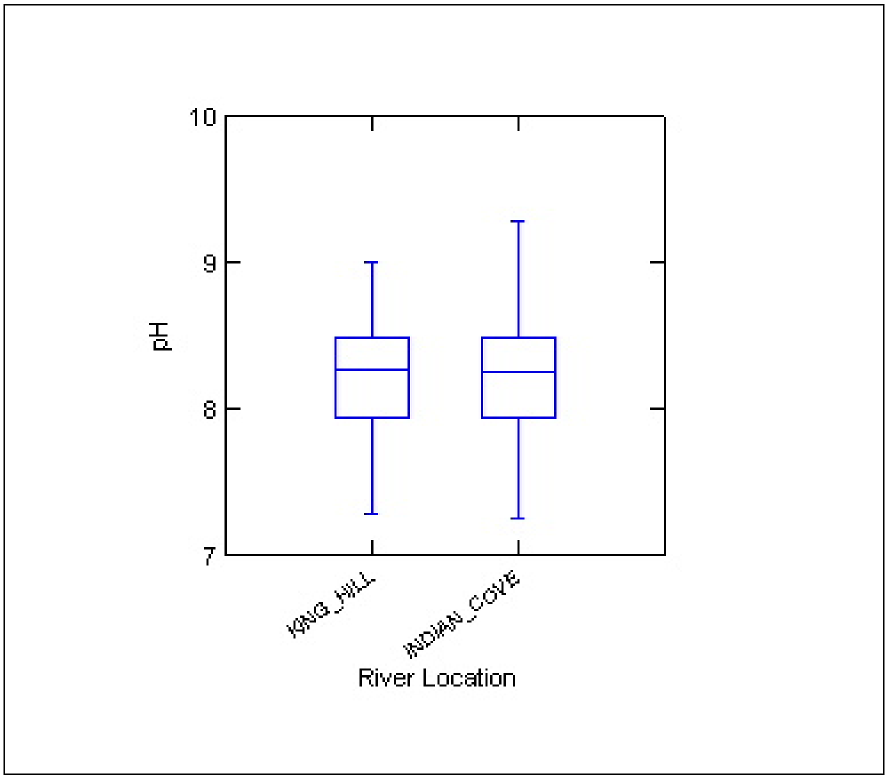

Figure 42. pH values at King Hill and Indian Cove, 1997-2002 all data.

Conclusions and Status of Beneficial Uses in the Snake River

The sediment data analysis shows that turbidity and suspended sediment levels in the Snake River between King Hill and Indian Cove are below the target concentrations and are at levels that would not be expected to impair cold water aquatic life beneficial uses. However, the presence of excess amounts of substrate-attached macrophytes indicates that substrate sediment is in excess. The macrophytes are impairing contact recreation and aesthetic beneficial uses. While no reductions will be necessary, DEQ will develop a suspended sediment TMDL with the intent of setting a benchmark that water column sediment levels in the river should not exceed. Additionally, DEQ recommends initiating substrate sampling in the years immediately following high flow years in the Snake River. The expectation is that in the year(s) following high velocity flushing flows, the macrophytic biomass levels will be significantly reduced. The intent of the additional sampling will be to characterize a "baseline" condition for which a potential substrate sediment TMDL can be developed. The intent of the TMDL would be to identify the amount of substrate sediment the river can assimilate before nuisance macrophytes begin to accumulate. Sediment levels beyond that assimilative capacity would be considered inappropriate.

The nutrient data analyses shows that TP concentrations exceed the target concentration at King Hill, but decrease between King Hill and Indian Cove. While the tributaries and the Glenns Ferry WWTP are sources of TP to the river, their relative contribution is diminutive when compared to the overall river load. Dissolved oxygen concentrations and pH values between King Hill and Indian Cove are within ranges established by the standards. However, suspended chlorophyll-a concentrations exceed the growing season mean target concentration. Again, this exceedance is impairing contact recreation beneficial uses. DEQ has developed a nutrient TMDL for the Snake River with the intent of decreasing TP concentrations at King Hill and reducing suspended chlorophyll-a concentrations to an acceptable level.

Table 20 summarizes the beneficial use support status throughout the Snake River between King Hill and Indian Cove as it relates to sediment and nutrients. Table 20 also outlines which TMDLs will be developed for the Snake River.

Table 20. Summary of Snake River water quality assessments for sediment and nutrients

Pollutant/Segment	Beneficial Uses Support Status	Impaired Use[1]	Comments
Sediment	--[2]	--	--
King Hill (RM 546.3) to Indian Cove (RM 525.3)	Impaired A sediment TMDL will be developed for the Snake River between King Hill and Indian Cove.	PCR, AES	Excess aquatic plant growth due to elevated levels of nutrient rich substrate sediment
Nutrients	--	--	--
King Hill (RM 546.3) to Indian Cove (RM 525.3)	Impaired A nutrient TMDL will be developed for the Snake River between King Hill and Indian Cove.	PCR, AES	Excess algae in the water column is causing development of algae scums

[1]CWAL: cold water aquatic life, SS: salmonid spawning, PCR: primary contact recreation, AES: aesthetics
[2]--: Cells left intentionally blank

Snake River Tributary Data Analysis

There are nine primary surface water tributaries that discharge to the Snake River between King Hill and Indian Cove. Of the nine tributaries, only King Hill Creek is not §303(d) listed. The remaining eight tributaries, as shown in Table 21, are §303(d) listed. The following sections describe each of the tributaries and assess the beneficial use support status as it relates to the §303(d) listed pollutant(s). Where the §303(d) pollutant is unknown, the assessment of beneficial use support status typically begins by evaluating sediment conditions. DEQ has determined that in Idaho, excess sediment is the pollutant that most often limits the full attainment of aquatic life beneficial uses.

Since no specific sediment criteria exist for the tributaries, surrogate targets to the narrative standard are used to assess sediment conditions in the tributaries. The targets are designed to account for both suspended sediment and substrate sediment and to be protective of cold water aquatic life. As opposed to the Snake River, the application of a substrate targets is possible. The targets are as follows:

<u>Suspended Sediment Concentration</u>

- **a geometric mean of 50 mg/L suspended sediment for no longer than 60 consecutive days**
- **a geometric mean of 80 mg/L suspended sediment for no longer than 14 consecutive days**

<u>Substrate Material (Particle Size Distribution)</u>

- **less than or equal to 30% fine material (particles less than 6.0 mm in diameter) in riffles**

The substrate material target is particularly useful in areas where bank erosion is the primary source of sediment. Eroding banks have the capability to contribute large amounts of multi-sized sediment particles to a stream in a short period. While the small, colloidal material will stay suspended and quickly disperse, the heavier material will settle to the bottom of the stream where it can adversely affect fish and macroinvertebrate communities, smothering fish nesting areas and fill pools—a critical habitat for rearing juveniles. Excess substrate sediment can also decrease intergravel dissolved oxygen concentrations by reducing the flow of water through the intergravel matrix. To prevent these adverse conditions from occurring, several researchers have recommended that riffles contain less than 30% fine material in order to protect trout spawning areas and macroinvertebrate communities (Bjorn and Reiser 1991, Rhodes et al. 1994, Witzell and MacCrimmon 1983).

It should also be noted that in assessing the upper, perennial segments of the streams only the substrate material target (30% fines) was applied. Human-induced elevated levels of suspended sediment are not expected in the upper segments because irrigated agriculture is not present.

Table 21. §303(d) tributaries to the Snake River between King Hill and Indian Cove

Stream Name	Boundary	§303(d) Pollutant	Designated Use(s)[1]
Alkali Creek	Headwaters to Snake River	Sediment	Undesignated
Bennett Creek	Headwaters to Snake River	Unknown	Undesignated
Browns Creek	Headwaters to Snake River	Sediment	Undesignated
Cold Springs Creek	Ryegrass Creek to Snake River	Unknown	Undesignated
Deadman Creek	Confluence of E. and W. Fork to Snake River	Sediment	Undesignated
Little Canyon Creek	Headwaters to Snake River	Sediment, Flow Alteration	Undesignated
Ryegrass Creek	Headwaters to Cold Springs Creek	Sediment	Undesignated
Sailor Creek	Headwaters to Snake River	Sediment	Undesignated

[1]For undesignated waters, the presumed uses are Coldwater Aquatic Life and Contact Recreation (Secondary for streams of this size)

None of the tributaries are designated for beneficial uses in the *Idaho Water Quality Standards and Wastewater Treatment Requirements*. IDAPA 58.01.01.101.01a says that undesignated waters should be protected for cold water aquatic life and contact recreation (primary or secondary, whichever is appropriate). Thus, the following assessments are based on the protection of cold water aquatic life and secondary contact recreation.

Sailor Creek, Deadman Creek and Browns Creek

Sailor, Deadman, and Browns Creeks are located on the south side of the Snake River. All three streams join the river in the Indian Cove area, as shown in Figure 43. For purposes of this assessment, Sailor, Deadman, and Browns Creeks are grouped together because from a water quality assessment standpoint there is very little to discuss. Appendix F illustrates that these streams are nearly always dry from their headwaters to the Snake River. The streams were visited in 1995, 1996, 1998, 2003, and 2004 and were found to be dry in all of those years. As a result, DEQ did not assess the streams any further from a water quality standpoint.

Bennett Creek

Bennett Creek is a 32.41-mile long stream that drains a 94 square mile (60,601 acre) watershed. Figure 44 shows the major characteristics of Bennett Creek. The elevation change in the watershed is approximately 3,377 feet with the elevation of the headwaters at about 5,870 feet and the mouth at about 2,493 feet. The headwaters of Bennett Creek are located in the Bennett Hills along U.S. Highway 20 about 2 miles south and 4 miles west of Little Camas Reservoir. After briefly flowing in a southwesterly direction along the highway, the stream turns and flows in a southeasterly direction through the Bennett Hills. The topography in this area is steep, as it often flows through narrow canyons. This segment typically flows year-around due to natural springs that feed the stream.

After exiting the Bennett Hills, the stream trends nearly due south through the valley above the Snake River Canyon (upper valley), over the steep terrace that overlooks the Snake River Canyon and eventually into the Snake River. As illustrated in Appendix F, this segment of stream is intermittent. From where the stream exits the Bennett Hills to where it enters the Snake River, Bennett Creek encounters several changes in land ownership, land use, and water quantity management. Within the upper valley area, the stream is primarily located on privately held rangeland, although parcels of irrigated cropland are common. The quantity of water in Bennett Creek is managed heavily by the local stakeholders in cooperation with the Idaho Department of Water Resource (IDWR). Water is withdrawn for irrigation purposes, stock water, and flood storage. Four dams exist on Bennett Creek in the upper valley area. Two of the dams are off-channel, while the other two are in-channel. Local stakeholders, in cooperation with IDWR, built the dams.

Once in the Snake River canyon, Bennett Creek is nearly all on private land. The land use also begins to transition from rangeland to irrigated cropland. Additionally, the King Hill Canal bisects the stream a few hundred meters south of Interstate 84. The King Hill Canal provides water to Bennett Creek as needed during the irrigation season. When the canal is not charging the stream, it is dry.

The segment of Bennett Creek that extends from the headwaters to the upper valley is the only portion that contains water year around. The lower segments contain water intermittently for irrigation purposes, but not long enough for a suitable aquatic life community to establish. Since the lower segments do not provide a significant pollutant load to the Snake River (see Snake River assessment above), only the upper segment is evaluated for beneficial use support status.

Sediment Analysis
As shown in Table 21, Bennett Creek is §303(d) listed for "unknown" pollutants and there are no designated beneficial uses meaning the stream is, by default, protected for cold water aquatic life. The §303(d) listing is based on the results of DEQ's 2003 Beneficial Use Reconnaissance Project (BURP) survey of the stream, which showed that in the upper, perennial segment the stream contained excessive amounts of fine material (particles <6.0 mm in diameter) on the stream bottom. The percentage of fine material was 51%, but a review of the BURP field form showed that the monitoring site was inadvertently located directly above a series of beaver complexes. As a result, these data are not used in this analysis in terms of comparing current conditions to the 30% fines target.

Using the Wolman (1954) pebble count procedure, DEQ re-measured the substrate material in the upper, perennial segment of Bennett Creek in July 2004. Particle size measurements were performed in a riffle approximately three miles above where the stream enters the upper valley. The segment of stream in which the measurements were performed is more representative of actual substrate conditions than the sample collected in 2003. The percentage of fine material was 18%, meaning that the target of 30% was not exceeded.

Aquatic Life (Fish) Distribution
Fish distribution data are very useful in determining the support status of cold water aquatic life. Different fish species and age classes have different ranges of tolerance to pollutants. Salmonid species (trout) are typically less tolerant to pollutants (such as excess sediment) than non-salmonids. Additionally, adult fish are more tolerant than juvenile fish. The presence of juveniles typically indicates that water quality is suitable for young fish to survive, and they indicate spawning success.

The Idaho Department of Fish and Game (IDFG) collected fish distribution data at four locations in Bennett Creek in July and August of 2002. Several age classes of redband trout were found in the upper, perennial segment of the stream. The lower segments were not sampled due to a lack of water. Figure 45 shows the number of fish and their respective size classes at each of the four locations. Figure 46 shows the location of each monitoring site.

The presence of three age classes of redband trout, including juveniles at all four sampling locations, further indicates that excess sediment is not impairing cold water aquatic life. The use appears to be fully supported.

Cold Springs Creek

Cold Springs Creek (Figure 47) is a 16.8-mile long stream that drains a 43.7 square mile (27,978 acre) watershed. The elevation change in the watershed is approximately 1,608 feet, with the elevation of the west fork and east fork confluence (headwaters) at about 4,101 feet and mouth at about 2,493 feet. The headwaters of the west fork are located in the Bennett Hills near Bennett Mountain, from which it flows for approximately 9.1 miles before it joins the east fork to form Cold Springs Creek. The topography in this area is steep, as the stream often flows through narrow canyons, and this segment typically flows year-around due to natural springs that feed the stream.

After exiting the Bennett Hills, the stream trends in a south to southwesterly direction through the upper valley above the Snake River canyon, over the steep terrace that overlooks the Snake River canyon and eventually into the Snake River. As illustrated in Appendix F, the segment of stream between the Bennett Hills and the Snake River Canyon is intermittent.

From where the stream exits the Bennett Hills to where it enters the Snake River, Cold Springs Creek is similar to Bennett Creek, encountering changes in land ownership, land use, and water quantity management. Within the upper valley area, the stream is primarily located on privately held rangeland, although parcels of irrigated cropland are common. The quantity of water in the stream is managed by the local stakeholders in cooperation with the Idaho Department of Water Resources, although not as heavily as Bennett Creek. Water is withdrawn for irrigation purposes, stock water, and flood storage. Once in the Snake River canyon, Cold Springs Creek is nearly all on private land. The land use also begins to transition from rangeland to irrigated cropland.

Two segments of Cold Springs Creek contain water all year around: the upper segment (headwaters to exit from Bennett Hills) and the lower segment (exit from upper valley to Snake River). The segment of stream in the upper valley is largely intermittent. The hydrology of these segments is better defined in Appendix F.

The upper and lower segments of Cold Springs Creek contain water year-around; the middle segment does not. Due to the intermittence of the middle segment, this segment will not be assessed for beneficial use support status. However, since the potential for the middle segment to contribute pollutants to the lower segment exists, pollutant reductions may be necessary. The application of these reductions will be discussed further in the TMDL section (Chapter 5).

Sediment Analysis

As was shown in Table 21, Cold Springs Creek is §303(d) listed for "unknown" pollutants, and there are no designated beneficial uses, meaning the stream is, by default, protected for cold water aquatic life. As described above, there are two perennial segments of Cold Springs Creek. Land uses in the upper segment are rangeland and riparian areas. Since the typical type of sediment loading associated with these land uses is bank erosion, the sediment condition analysis for this segment is based on meeting the 30% substrate fines target.

Using the Wolman (1954) pebble count procedure, DEQ measured the substrate material in the upper segment of Cold Springs Creek in July 2004. Particle size measurements were performed approximately 1.5 miles below where the stream exits the upper canyon, so the stream was nearly dry. Unfortunately, access was not gained above this location, so it is not certain that the measured segment is entirely representative of the upper segment. However, it is likely that the particle size distribution above the sampling point contains even less fine material due to the limited access to the stream banks. The percentage of fine substrate material was 26%, meaning that the target of 30% was not exceeded.

Land uses in the lower segment of Cold Springs Creek are a mix of rangeland and irrigated cropland. As such, the sediment condition analysis for this segment is based on meeting the 30% substrate fines target and the durational water column targets of 50 mg/L and 80 mg/L SSC.

Wolman pebble counts were performed in two locations in the lower segment of Cold Springs Creek in March and April of 2004. In March, counts were performed directly above where the stream crosses Interstate 84 (0.5 mile from the river). In April, counts were performed approximately 1.5 miles upstream from the Snake River. The percentage of fine substrate material at each site was 35% and 33%, respectively, meaning that the target of 30% is slightly exceeded. A survey of the stream correspondingly showed that the stream banks are eroding in several locations, such that less than 80% of the banks are stable.

The Data Assessment Methods section of this document describes the linkage that has been developed between 80% bank stability and maintaining less than 30% fine substrate material in riffles. This linkage was used to develop TMDLs for the lower segment of Cold Springs Creek. The TMDL portion (Chapter 5) will identify the reductions necessary to meet the 30% fines substrate target.

In addition to assessing the particle size distribution in the lower segment of Cold Springs Creek, DEQ also collected SSC samples to compare to the water column targets. Samples were collected in the same locations as the pebble counts at the end of March 2003. The concentration at the site 0.5 miles from the river was 31 mg/L while the concentration at the site 1.5 miles above the river was 19 mg/L. Both are below the most stringent durational target of 50 mg/L.

Aquatic Life (Fish) Distribution

Fish distribution data are very useful in determining the support status of cold water aquatic life. Different fish species and age classes have different ranges of tolerance to pollutants. Salmonid species (trout) are typically less tolerant to pollutants (such as excess sediment) than non-salmonids. Additionally, adult fish are more tolerant than juvenile fish. The presence of juveniles typically indicates that water quality is suitable for young fish to survive and also indicates spawning success.

Idaho Fish and Game collected fish distribution data at a single location in the upper, perennial segment of Cold Springs Creek in July 2002. Several age classes of redband trout were found in the stream. The lower segment of the stream was not sampled. Figure 48 shows the number of fish within each size class. Figure 46 (above) shows the location of each monitoring site.

The presence of three age classes of redband trout, including several juveniles further indicates that excess sediment is not impairing cold water aquatic life in the upper segments. Since there are hydrologic boundaries between the upper and lower site, these fish data are not used to determine support status in the lower segment. The lack of aquatic life information in the lower segment remains a data gap.

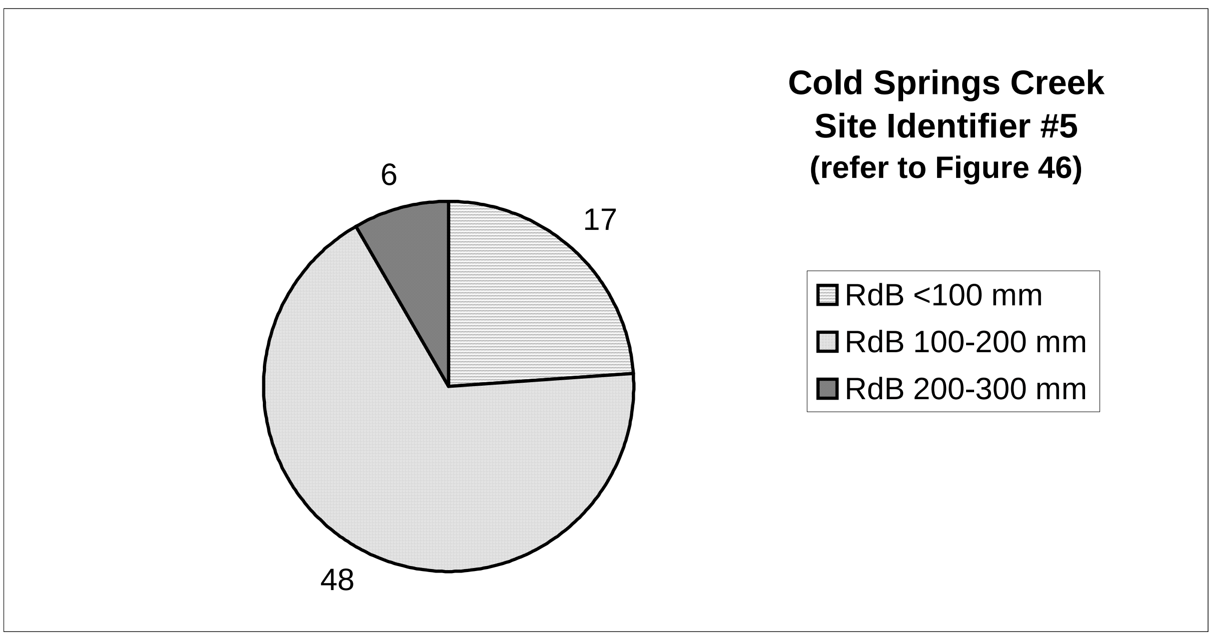

Figure 48. Redband trout (RdB) size distribution (length in mm) in the upper, perennial segment of Cold Springs Creek, IDFG 2002 data.

Ryegrass Creek

Ryegrass Creek is a 15.7-mile long stream that drains a 28.7 square mile (18,386 acre) watershed. Figure 47 (above) shows the major characteristics of Ryegrass Creek. The elevation change in the watershed is approximately 1,755 feet, with the elevation headwaters at about 4,822 feet and the confluence with Cold Springs Creek at about 3,067 feet. The headwaters of Ryegrass Creek are located in the Bennett Hills approximately six miles south of Bennett Mountain. The stream meanders in a southerly direction for its entirety until it joins Cold Springs Creek. The topography in the headwaters and for the first two miles of the stream is steep. This segment typically flows year-round due to the natural springs that feed the stream.

After exiting the Bennett Hills, the stream moves through the upper valley above the Snake River canyon until it joins Cold Springs Creek. As illustrated in Appendix F, the segment of stream between the Bennett Hills and Cold Springs Creek is intermittent.

From where the stream exits the Bennett Hills to where it enters Cold Springs Creek, some changes in land ownership, land use, and water quantity management are encountered. The stream is primarily located on privately held rangeland, but parcels of irrigated cropland are common. The quantity of water in the stream is managed by the local stakeholders in cooperation with the Idaho Department of Water Resource. Water is withdrawn for irrigation purposes, stock water, and flood storage.

Only the upper segment of Ryegrass Creek (in the Bennett Hills) contains water all year-around. This segment is defined as the upper (headwaters to exit from Bennett Hills) segment. The lower, intermittent segment extends from where the stream exits the Bennett Hills to Cold Springs Creek. The hydrology of these segments is better defined in Appendix F.

The upper segment of Ryegrass Creek contains water all year around; the lower segment does not. Due to the intermittence of the lower segment, this segment will not be assessed for beneficial use support status. However, since the potential for the lower segment to contribute pollutants to Cold Springs Creek exists, pollutant reductions may be necessary. The application of these reductions will be discussed further in the TMDL section (Chapter 5).

Sediment Analysis

As shown in Table 21, Ryegrass Creek is §303(d) listed for sediment and there are no designated beneficial uses meaning the stream is, by default, protected for cold water aquatic life. As described above, only the upper segment of the stream is perennial. Land uses in the upper segment are primarily rangeland. Since the typical type of sediment loading associated with this land use is bank erosion, the sediment condition analysis for this segment is based on meeting the 30% substrate fines target.

Using the Wolman (1954) pebble count procedure DEQ measured the substrate material in the upper segment of Ryegrass Creek in September 2004. Particle size measurements were performed approximately one mile below where the stream exits the upper canyon. Unfortunately, access was not gained above this location. Thus, it is not certain that the measured segment is entirely representative of the upper segment. However, it is likely that the particle size distribution above the sampling point contains even less fine material due to less access to the stream banks. The percentage of fine substrate material was 19%, meaning that the target of 30% was not exceeded.

Aquatic Life (Fish) Distribution

Fish distribution data are not available for Ryegrass Creek. This remains a data gap that needs to be filled when additional resources become available.

Alkali Creek

Alkali Creek is a 16.4-mile long stream that drains a 35.8 square mile (22,945 acre) watershed. Figure 49 shows the major characteristics of Alkali Creek. The elevation change in the watershed is approximately 1,526 feet, with the elevation of the headwaters at about 4,019 feet and mouth at about 2,493 feet. The headwaters of Alkali Creek are located at the base of the Bennett Hills approximately three miles north of Blair Trail Reservoir. The stream trends in a southwesterly direction through the upper valley until it meets the terrace that borders the Snake River canyon. The topography in the headwaters is not as steep as the other tributaries because the headwaters do not extend as far into the Bennett Hills. After dropping into the Snake River canyon, Alkali Creek trends in a south to southeasterly direction until it enters the Snake River.

From where the stream exits the Bennett Hill to where it drops into the Snake River canyon, Alkali Creek is intermittent. The hydrology of these segments is better defined in Appendix F. Over the length of the stream, Alkali Creek encounters changes in land ownership, land use, and water quantity management. Within the upper valley area the stream is primarily located on rangeland held by the Bureau of Land Management, although parcels of irrigated privately held rangeland and cropland are present. The quantity of water in the stream is managed by the local stakeholders in cooperation with the Idaho Department of Water Resource. Water is withdrawn for irrigation purposes, stock water, and flood storage. Once in the Snake River canyon, Alkali Creek is on a mix of BLM and private land. There is also less irrigated cropland that some of the adjacent tributaries. Much of the stream below the canyon flows through a privately held elk farm.

As noted above, two segments of Alkali Creek contain water all year-around. These segments are defined as the upper (headwaters to exit from Bennett Hills) and lower (exit from upper valley to Snake River). The segment of stream in the upper valley is largely intermittent. The hydrology of these segments is better defined in Appendix F.

The upper and lower segments of Alkali Creek contain water all year-around; the middle segment does not. Due to the intermittence of the middle segment, this segment will not be assessed for beneficial use support status. However, since the potential for the middle segment to contribute pollutants to the lower segment exists, pollutant reductions may be necessary. If so, the application of these reductions will be discussed further in the TMDL section (Chapter 5).

Sediment Analysis

As shown in Table 21, Alkali Creek is §303(d) listed for sediment and there are no designated beneficial uses meaning the stream is, by default, protected for cold water aquatic life. As described above, only the upper and lower segments of the stream are perennial. The primary land use in both segments is rangeland. Since the typical type of sediment loading associated with this land use is bank erosion, the sediment condition analysis for this segment is based on meeting the 30% substrate fines target. However, due to the presence of the elk farm on the lower segment, SSC will also be evaluated to ensure that irrigated pasture related sediment is not in excess.

Using the Wolman (1954) pebble count procedure, DEQ measured the substrate material in the upper segment of Alkali Creek in September 2004 and the lower segment in March 2004. In the upper segment, pebble counts were performed approximately one-half mile below where the stream exits the upper canyon. Thus, it is not certain that the measured segment is entirely representative of the upper segment. However, it is likely that the particle size distribution above the sampling point contains even less fine material due to less access to the stream banks. The percentage of fine material in the upper segment was 30%, which is equal to the target of 30%.

In the lower segment, pebble counts were performed approximately one mile up from the Snake River (above the elk ranch) and approximately 200 meters up from the Snake River (below the elk ranch). The percentage of fine substrate material at the two sites on the lower segment were 10% and 6%, respectively. Both percentages are below the target of 30%.

In addition to assessing the particle size distribution in the lower segment of Alkali Creek, DEQ also collected SSC samples to compare to the water column targets. Samples were collected in the same locations as the pebble counts at the end of March 2003. The concentration at the site above the elk ranch was 7.4 mg/L, while the concentration at the site below the elk ranch was 9.1 mg/L. Both are below the most stringent durational target of 50 mg/L.

Aquatic Life (Fish) Distribution

Fish distribution data are not available for Alkali Creek. This remains a data gap that needs to be filled when additional resources become available.

Little Canyon Creek

Little Canyon Creek is a 28.8-mile long stream that drains a 55 square mile (35,513 acre) watershed. Figure 50 shows the major characteristics of Little Canyon Creek. The elevation change in the watershed is approximately 4,134 feet, with the elevation of the headwaters at about 6,627 feet and mouth at about 2,493 feet. The headwaters of Little Canyon Creek are located in the Bennett Hills near Bennett Mountain. Little Canyon Creek flows in a southeasterly direction from its headwaters to where the stream exits the Bennett Hills. The topography in this area is steep, as it often flows through narrow canyons. This segment typically flows year-around due to natural springs that feed the stream.

After exiting the Bennett Hills, the stream turns to the southwest and moves through the valley above the Snake River canyon (upper valley). As illustrated in Appendix F, this segment of stream is intermittent. From where the stream exits the Bennett Hill to where it meets the steep terrace above the Snake River canyon, Little Canyon Creek encounters several changes in land ownership, land use and water quantity management. Within the upper valley area the stream is primarily located on federally held rangeland, although parcels of privately held irrigated cropland are common. The quantity of water in Little Creek is managed by the local stakeholders in cooperation with the Idaho Department of Water Resource. Water is withdrawn for irrigation purposes, stock water, and flood storage.

Once in the Snake River canyon, Little Canyon Creek is nearly all on private land. The land use also begins to transition from rangeland to irrigated cropland and urban/suburban uses, although some rangeland is still available. In addition, the stream flows directly through the town of Glenns Ferry approximately three miles before it enters the Snake River. The entire segment of stream in the Snake River canyon is perennial.

The segment of Little Canyon Creek located in the upper valley is intermittent. Due to the intermittence of this segment, it will not be assessed for beneficial use support status. However, since the potential for this segment to contribute pollutants the lower portion of Little Canyon Creek exists, pollutant reductions may be necessary. The application of these reductions will be discussed further in the TMDL section (Chapter 5).

Sediment Analysis

As shown in Table 21, Little Canyon Creek is §303(d) listed for sediment and there are no designated beneficial uses meaning the stream is, by default, protected for cold water aquatic life. As described above, there are two perennial segments of Little Canyon Creek, the upper and lower segments. Land uses in the upper segment are rangeland and riparian areas. Since the typical type of sediment loading associated with these land uses is bank erosion, the sediment condition analysis for this segment is based on meeting the 30% substrate fines target.

Using the Wolman (1954) pebble count procedure, DEQ measured the substrate material at two locations in the upper segment of Little Canyon Creek in March 2004. Particle size measurements were performed approximately 2.0 and 3.0 miles above where the stream exits the upper canyon. The percentage of fine substrate material was 14% and 22%, respectively, meaning that the target of 30% was not exceeded.

Land uses in the lower segment of Cold Springs Creek are a mix of rangeland and irrigated cropland and urban/suburban uses. As such, the sediment condition analysis for this segment is based on meeting the 30% substrate fines target and the durational water column targets of 50 mg/L and 80 mg/L SSC.

Wolman pebble counts were performed in two locations in the lower segment of Little Canyon Springs Creek in March and May of 2004. In March, counts were performed approximately 1.5 miles above Glenns Ferry in a rangeland area. In May, the counts were performed approximately 2 miles above Glenns Ferry in a rangeland/irrigated cropland area. The percentage of fine substrate material at each site was 85% and 34%, respectively, meaning that the target of 30% is exceeded. A survey of the stream correspondingly showed that the stream banks are eroding in several locations such that less than 80% of the banks are stable. This is especially the case in the segment where the percentage of fine material is 85%. Attempts were also made to access the stream below the city of Glenns Ferry, but access was denied. Thus, it is conservatively assumed that that fine substrate material also exceeds 30% in the segment of stream below Glenns Ferry.

The Data Assessment Methods section of this document describes the linkage that has been developed between 80% bank stability and maintaining less than 30% fine substrate material in riffles. This linkage was used to develop TMDLs for the lower segment of Little Canyon Creek. The TMDL portion (Chapter 5) identifies the reductions necessary to meet the 30% fines substrate target.

In addition to assessing the particle size distribution in the lower segment of Little Canyon Creek, DEQ also collected an SSC sample to compare to the water column targets. A sample was collected approximately 1.5 miles above Glenns Ferry (in the same location as the pebble count) in March 2004. The SSC concentration at the site was 15 mg/L, which is below the most stringent durational target of 50 mg/L.

Aquatic Life (Fish) Distribution

Fish distribution data are very useful in determining the support status of cold water aquatic life. Different fish species and age classes have different ranges of tolerance to pollutants. Salmonid species (trout) are typically less tolerant to pollutants (such as excess sediment) than non-salmonids. Additionally, adult fish are more tolerant than juvenile fish. The presence of juveniles typically indicates that water quality is suitable for young fish to survive and they indicate spawning success.

IDFG collected fish distribution data at eight locations in the upper, perennial segment of Little Canyon Creek in June and July of 2002. Several age classes of redband trout were found in the stream. Young-of-the-year (born that year) rainbow trout were located as well. The lower segment of the stream was not sampled. Figure 51 shows the number of fish within each size class. Figure 46 (above) shows the location of each monitoring site.

The presence of three age classes of redband trout, including several juveniles, as well as the presence of juvenile rainbow trout further indicates that excess sediment is not impairing cold water aquatic life in the upper segments. Since there are hydrologic boundaries between the upper and lower site, these fish data were not used to determine support status in the lower segment. The lack of aquatic life information in the lower segment remains a data gap.

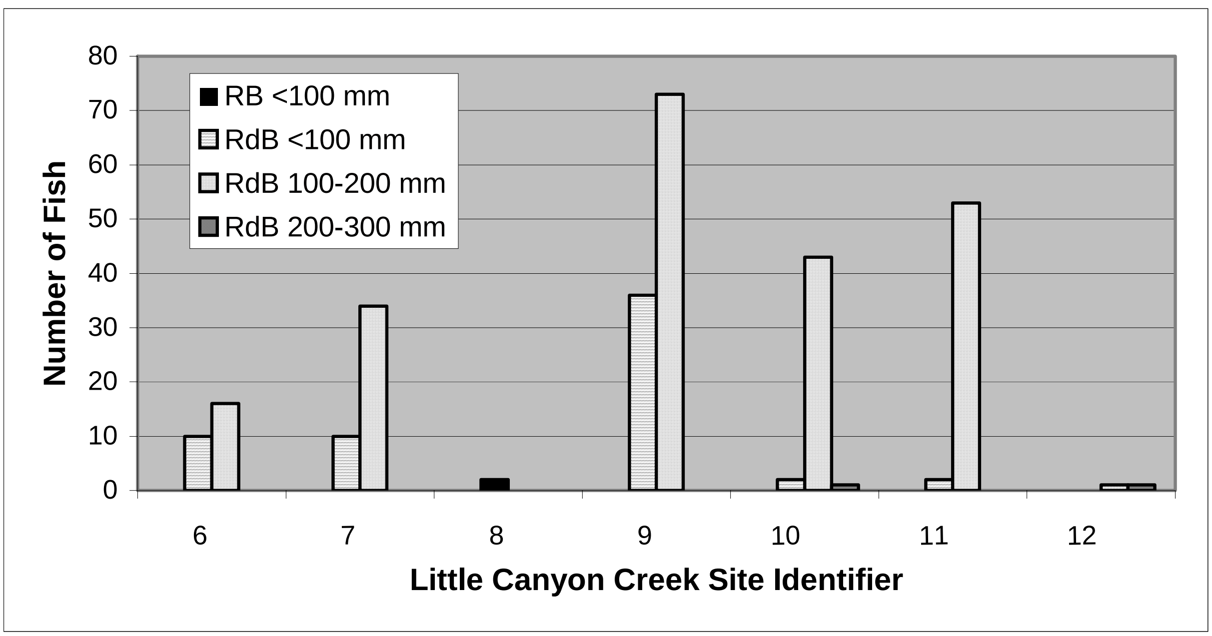

Figure 51. Fish distribution (length in mm) in the upper, perennial segment of Little Canyon Creek, IDFG 2002 data.

Conclusions and Status of Beneficial Uses in Tributaries

The combination of sediment and aquatic life data for the Cold Springs and Little Canyon Creeks show that excess substrate sediment is impairing cold water aquatic life in the lower segments. As a result, TMDLs are necessary for these segments. The data also shows that the middle segments of Cold Springs and Little Canyon Creeks are intermittent. As such, a beneficial use support status analysis was not performed (Appendix F). However, since these segments may provide sediment to the lower segments, TMDLs may be necessary. The data for the upper segments show that uses are not impaired.

Beneficial uses do not appear to be impaired in Bennett, Ryegrass, or Alkali Creeks. TMDLs are not recommended for these streams. The data also show that Deadman, Sailor, and Browns Creeks are dry essentially all of the time. Thus, no further assessments were made on these streams.

Table 22 summarizes the beneficial use support status for the §303(d) listed tributaries in HUC 17050101. Table 22 also outlines where TMDLs will be developed on the tributaries.

Table 22. Summary of the water quality assessments for 303(d) tributaries in HUC 17050101

Pollutant / Segment	Beneficial Uses Support Status	Impaired Use[1]	Comments
Deadman Creek	Not Impaired	None	Intermittent Stream[2]
Sailor Creek	Not Impaired	None	Intermittent Stream[2]
Browns Creek	Not Impaired	None	Intermittent Stream[2]
Bennett Creek			
-Upper Segment	Not Impaired	None	Based on fish and particle size distribution data
-Lower Segment	Not Impaired	None	Intermittent Stream[2]
Ryegrass Creek			
-Upper	Not Impaired	None	Based on particle size distribution data
-Lower	Not Impaired	None	Intermittent Stream[2], a TMDL may be necessary to prevent sediment loading in Cold Springs Creek
Cold Springs Creek			
-Upper Segment	Not Impaired	None	Based on fish and particle size distribution data
-Middle Segment	Not Impaired	None	Intermittent Stream[2], a TMDL may be necessary to prevent sediment loading in the lower segment
-Lower Segment	Impaired	CWAL	Based on particle size distribution data, a TMDL to reduce bank erosion is necessary
Alkali Creek			
-Upper Segment	Not Impaired	None	Based on particle size distribution data
-Middle Segment	Not Impaired	None	Intermittent Stream
-Lower Segment	Not Impaired	None	Based on particle size distribution and SSC[3] data
Little Canyon Creek			
-Upper Segment	Not Impaired	None	Based on fish and particle size distribution data
-Middle Segment	Not Impaired	None	Intermittent Stream[2], a TMDL may be necessary to prevent sediment loading in the lower segment
-Lower Segment	Impaired	CWAL	Based on particle size distribution data, a TMDL to reduce bank erosion is necessary

[1]CWAL: cold water aquatic life, [2]See Appendix F for further explanation, SSC: suspended sediment concentration

C.J. Strike Reservoir Data Analysis

C.J. Strike Reservoir is located in the western end of the King Hill-C.J. Strike subbasin. The reservoir encompasses approximately 7,650 surface acres and a volume of about 226,800 acre-feet at full pool. Figure 52 shows a location overview of C.J Strike Reservoir within Idaho. The C.J. Strike Hydroelectric Project and the ensuing reservoir were constructed in 1952 to help meet the growing demand for electricity in southern Idaho (Idaho Power Company 1998). The project currently operates under a newly issued license from the Federal Energy Regulatory Commission. The previous license expired in the year 2000.

Reservoir Flow and Physical Characteristics

Unlike many reservoirs in southwestern Idaho, C.J Strike Reservoir does not store water for the irrigation season only. There is very little active storage. The mean daily flows entering and leaving the reservoir are nearly equal, meaning that the reservoir experiences very little daily water level fluctuations (Idaho Power Company 1998). C.J. Strike Reservoir receives water from two primary sources:

- Entering from the east, the Snake River is by far the largest source of water to the reservoir. The average annual discharge from the Snake River is 10,370 cfs resulting is a total annual flow of near 8 million acre-feet (Brennan et al. 1996b).
- Entering from the southeast, the Bruneau River has a mean annual discharge of 388 cfs contributing a total annual flow of 273,000 acre-feet (Brennan et al. 1996b).

As illustrated in Figure 52, C.J. Strike Reservoir has two distinct branches. Corresponding to its volumetric contribution, the Snake River branch is the largest, extending from Indian Cove (Snake River mile 525) to the C.J. Strike Dam (Snake River mile 494). The Bruneau River branch of the reservoir, extending from the confluence of the Bruneau River and the Snake River (Bruneau River mile 0) to about Bruneau River mile 6.5, fluctuates somewhat because of wetland conditions where the Bruneau River enters the reservoir. The confluence of the Bruneau River and the Snake River are within the body of the reservoir.

Steep basalt cliffs bind most segments of C.J. Strike Reservoir, with much of the reservoir canyon resembling a trench cut into the plain (Idaho Power Company 1998). Figure 53 gives an example of the typical topography surrounding C.J. Strike Reservoir. At about 2,164 acres, the Bruneau River arm consists of the Bruneau Pool and the Bruneau narrows. The Bruneau Pool has a maximum depth of about 10 meters, while the narrows are much deeper (Idaho Power Company 1998). The Snake River arm consists of a large open pool just east and northeast of the dam. Above the pool, the reservoir begins to constrict (see Figures 52 and 53) and becomes narrow and deep. In some locations, the reservoir reaches nearly 100 feet deep, although the mean depth for the entire Snake River arm is 33 feet (Idaho Power Company 1998).

Pesticides Loading Analysis

C.J. Strike Reservoir (Snake River arm) is the only water body in HUC 17050101 listed for pesticides. The pesticides evaluated as part of this assessment focus on total-DDT (1,1,1-trichloro-2,2-bis(p-chlorophenyl) ethane, CAS #50-29-3) including its metabolites DDD (1,1-dichloro-2,2-bis(p-chlorophenyl) ethane, CAS #72-54-8) and DDE (1,1-dichloro-2,2-bis(chlorophenyl) ethylene, CAS #72-55-9) and dieldrin (1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-endo, exo-1,4:5,8-dimethanonaphthalene, CAS #60-57-1). The water quality standards/target values specific to these pesticides are described below. The values are based on a combination of standards and targets established by the downstream Snake River-Hells Canyon TMDL (17050115) (IDEQ 2004) and the *Idaho Water Quality Standards and Water Treatment Requirements* adoption of the U.S. EPA guidance (EPA 1992).

The water column targets that will be used for the C.J. Strike Reservoir assessment of pesticides are as follows:

- **total-DDT (t-DDT):**
  1. **Aquatic Life: less than 0.001µg/L water column concentration**
  2. **Domestic Water Supply: less than 0.00059 µg/L water column concentration**

- **Dieldrin**
  1. **Aquatic Life: less than 0.0019µg/L water column concentration**
  2. **Domestic Water Supply: less than 0.00014 µg/L water column concentration**

The domestic water supply targets are based on a carcinogenic risk of 10^{-6}. That is, given the concentration in the water, there is a 1 in 1,000,000 chance of developing t-DDT or dieldrin induced cancer.

In addition to the detailed DDT and dieldrin analysis, the King Hill-C.J. Strike Reservoir watershed advisory group also requested an evaluation of several other pesticides. This analysis was performed if two criteria were met: a) the water column concentration data were available, and b) a standard for that given pesticide existed within the *Idaho Water Quality Standards and Water Treatment Requirements.* Based on these criteria, additional analyses were performed for aldrin, endrin, heptachlor, heptachlor epoxide, lindane, alpha-HCH, and dacthal.

t-DDT and Dieldrin Characteristics

While neither t-DDT nor dieldrin are highly water-soluble; both compounds readily adsorb onto suspended and benthic particles within the water system. At some point, the suspended particles are typically deposited on a stream, lake, or reservoir bottom. The particle can then become resuspended and transported in a similar fashion to a downstream location—a process is called *pollutant cycling*. Aquatic organisms, especially bottom-feeding species such as suckers and carp, are vulnerable to the bioaccumulation of these compounds as they move through the system.

t-DDT and dieldrin are persistent, long-lived contaminants. As such, even though their use has been discontinued, they are expected to remain in the environment for the foreseeable future (US EPA 1992a). This problem is evident throughout the United States: in a national US EPA study (US EPA 1992a), over 90% of 388 sites sampled nationwide in 1986 and 1989 showed concentrations of p,p'DDE (a metabolite of DDT) and PCBs.

DDT

DDT is an anthropogenic chemical that was widely used pre-1973 to control insects on agricultural crops and insects that carry dangerous diseases, such as malaria and typhus. On a global scale, the use of DDT increased substantially after the Second World War. DDT appeared to be the ideal insecticide in that it was cheap to manufacture and of relatively low toxicity to mammals (oral Lethal Dose 50 is 300 to 500 mg/kg). However, concern over environmental effects began to appear in the late 1940s. Many species of insects were able to develop a resistance to DDT so that it was no longer as effective as a control mechanism. In addition, DDT was also discovered to be highly toxic to fish (ATSDR 2001, Harrison 2001). Due to the risk it presented to wildlife, and with potential human health concerns being raised, the use of DDT was banned in 1973 in the United States except for public health emergencies.

The chemical stability of DDT and its tendency to bioaccumulate in fatty tissues add to the complexity of the problem. DDT is not metabolized (broken down by cells) rapidly; rather it is stored in fatty tissues within the body. As an average, about eight years are required for an animal to metabolize half of the DDT it assimilates (this eight years is known as the biological half-life). Therefore, if an animal continues to ingest DDT at a steady rate, its tissue concentration will increase over time (Harrison 2001).

Dieldrin

Dieldrin is a man made chlorinated insecticide that was popular for crops, such as corn and cotton, from 1950 to 1970. Dieldrin does not occur naturally in the environment. Due to concerns about damage to the environment and the potential harm to human health, EPA banned all uses of dieldrin, except to control termites, in 1974. In 1987, EPA banned dieldrin for all uses.

As with DDT, dieldrin is a very stable chemical and tends to bioaccumulate in fatty tissues. Dieldrin is not metabolized rapidly and exits the body very slowly (ATSDR 2001). Because dieldrin is bioaccumulative, it does not break down easily in the environment and becomes increasingly concentrated as it moves up the food chain to humans and other wildlife. (US EPA PBT 2001).

Sources of DDT and Dieldrin

DDT and dieldrin compounds entered surface water systems primarily from agricultural nonpoint source runoff and atmospheric deposition. Because the compounds have been banned from use in the U.S. since 1973 and 1987, respectively, the primary sources of these compounds in surface waters are legacy deposition and continued agricultural runoff from previously treated areas. (This analysis was done under the assumption that there are no current sources of DDT and dieldrin to the system.) Additionally, organochlorine insecticides are man-made compounds; no natural sources for these compounds exist at any significant level.

Data Availability in the Snake River and C.J. Strike Reservoir

The United States Geologic Survey (USGS) extensively monitored pesticides and trace metals in the Snake River system from 1992 through 1997 (Maret and Ott 1997, Clark and Maret 1998). Total-DDT and dieldrin levels in fish tissues and sediment were evaluated. The data showed that concentrations of both t-DDT and organochlorine compounds increased in the distance downstream (over the entire Snake River study area). As expected, reservoir concentrations were somewhat higher overall than tributary concentrations, but the downstream increase was evident in both types of surface waters. None of the DDT fish tissue samples exceeded the EPA action level of 1000 µg/kg, and dieldrin levels were always below the 5.0 µg/kg detection limit. Table 23 shows the fish tissue data specific to the King Hill-C.J. Strike basin (HUC 17050101), as presented in Maret and Ott 1997 and Clark and Maret 1998.

Table 23. USGS data showing t-DDT and dieldrin fish tissue data for King Hill and C.J. Strike Reservoir

Location	Year	Species	Pesticide	Concentration (µg/kg)	NAS/NAE[1] Exceeded
C.J. Strike Reservoir[2]	1997	Yellow perch, fillet	t-DDT	11	No
C.J. Strike Reservoir	1997	Sucker	t-DDT	232	No
King Hill	1997	Sucker	t-DDT	187	No
C.J. Strike Reservoir	1997	Sucker	Dieldrin	< 5	No
C.J. Strike Reservoir	1997	Bass	Dieldrin	< 5	No
C.J. Strike Reservoir	1997	Yellow perch, fillet	Dieldrin	< 5	No
King Hill	1997	Sucker	Dieldrin	< 5	No
King Hill	1992	Sucker	Dieldrin	< 5	No
King Hill	1992	Sucker	Dieldrin	< 5	No
King Hill	1993	Sucker	Dieldrin	< 5	No
King Hill	1994	Sucker	Dieldrin	< 5	No
King Hill	1992	Sucker	t-DDT	171	No
King Hill	1992	Sucker	t-DDT	308	No
King Hill	1993	Sucker	t-DDT	177	No
King Hill	1994	Sucker	t-DDT	213	No

[1] NAS/NAE: National Academy of Sciences/National Academy of Engineering (1973) recommended maximum concentrations in whole-body fish for the protection of fish eating wildlife: 1000 µg/kg t-DDT, 100 µg/kg dieldrin.
[2] All C.J. Strike Data collected at Loveridge Bridge, which is the inflow for C.J. Strike Reservoir.

It should be noted that the C.J. Strike Reservoir DDT and dieldrin data presented in Table 23, and used from this point forward were collected at Loveridge Bridge, which represents the transitional zone (from river to reservoir) in C.J. Strike Reservoir. The Loveridge Bridge data are used to represent all of C.J. Strike Reservoir, because very little pesticides data exists for the lacustrine (deepest) portion of the reservoir (two data points). The concept of using Loveridge Bridge data to represent the entire reservoir from a pesticides standpoint was introduced by Clark and Maret (1998).

A general comparison between the King Hill and C.J. Strike fish tissue t-DDT concentrations suggests that the concentrations may be similar. The mean concentration in sucker tissues collected from King Hill is 211 µg/kg (n = 5), while the concentration of a single sucker sample collected from C.J. Strike is 232 µg/kg. While this interpretation suggests a similarity, the fish tissue t-DDT concentrations are not robust enough to conclude whether there is a substantive increase or decrease in tissue concentration between King Hill and C.J. Strike Reservoir. The dieldrin data offer little comparative insight as well. Fish tissue samples collected at both King Hill and C.J. Strike fall below the 5.0 µg/l detection limit, making a comparison difficult.

One conclusion that can be reached based on the data in Table 23 is that the reported t-DDT and dieldrin fish tissue concentrations are well below the National Academy of Sciences and National Academy of Engineering action levels for the protection of predatory wildlife. This conclusion will be further expanded upon in terms of beneficial use support status at the conclusion of this pesticides analysis.

The bed sediment t-DDT and dieldrin data offer little additional insight into the pesticide conditions in C.J. Strike Reservoir or a comparison between King Hill and C.J. Strike Reservoir, again primarily due to the lack of a robust data set. Table 24 shows the bed-sediment data as presented by Maret and Ott 1997 and Clark and Maret 1998.

Table 24. USGS data showing DDT and dieldrin bed-sediment data for King Hill and C.J. Strike Reservoir

Location	Year	Pesticide	Concentration (µg/kg)
C.J. Strike Reservoir[1]	1997	p,p'-DDT	1.1
C.J. Strike Reservoir	1997	Dieldrin	<1.0
King Hill	1997	p,p'-DDT	.40
King Hill	1997	Dieldrin	<1.0
King Hill	1992	t-DDT	ND[2]
King Hill	1992	t-DDT	ND
King Hill	1993	t-DDT	ND
King Hill	1994	t-DDT	13

[1] All C.J. Strike Data collected at Loveridge Bridge, which is the inflow for C.J. Strike Reservoir.
[2] Not Detected

The bed-sediment p,p'-DDT concentration at C.J. Strike Reservoir in 1997 is nearly three times the concentration at King Hill for the same year, remaining consistent with the findings of Clark and Maret 1998, which suggested that concentrations increase in the downstream direction. However, the 1992-1994 t-DDT data at King Hill show that the concentration ranges from "non-detect" in 1992 and 1993 to 13 µg/kg in 1994. This variation in concentration suggests that the difference between King Hill and C.J. Strike Reservoir in 1997 should be interpreted with caution.

The dieldrin concentrations at C.J. Strike Reservoir and King Hill in 1997 were both less than the detection limit of 1.0 µg/kg, again making a direct comparison difficult.

Water Column t-DDT and Dieldrin

As noted above, the fish tissue and bed sediment t-DDT and dieldrin data are not particularly robust. While the data do offer some insight into the relative levels of each pesticide in the fish tissue and sediment, they do not offer an explicit linkage to the beneficial use support status of aquatic life and domestic water supply in C.J. Strike Reservoir. To create this critical linkage, a method to estimate the water column concentration in C.J. Strike Reservoir was developed. The intent was to compare the estimated concentration to the water quality targets outlined above to determine beneficial use support status.

Over the past several years, the USGS has collected t-DDT and dieldrin water column data from King Hill. These data are used to develop bioaccumulation factors (BAF) for t-DDT and dieldrin, which provide a means to estimate the water column concentration of each pesticide. Bioaccumulation is described as the process by which an organism accumulates a substance in its body as a result of uptake from all environmental sources (water, food, sediment, etc.). A bioaccumulation factor is described as the ratio of the concentration of a substance in tissue to its concentration in ambient water. The concept of bioaccumulation and the use of bioaccumulation factors applies well to persistent pesticides, such as t-DDT and dieldrin, because their chemical structure does not rapidly breakdown in the environment. Figure 54 shows a hypothetical example of how DDT, an organochlorine, can bioaccumulate in the environment.

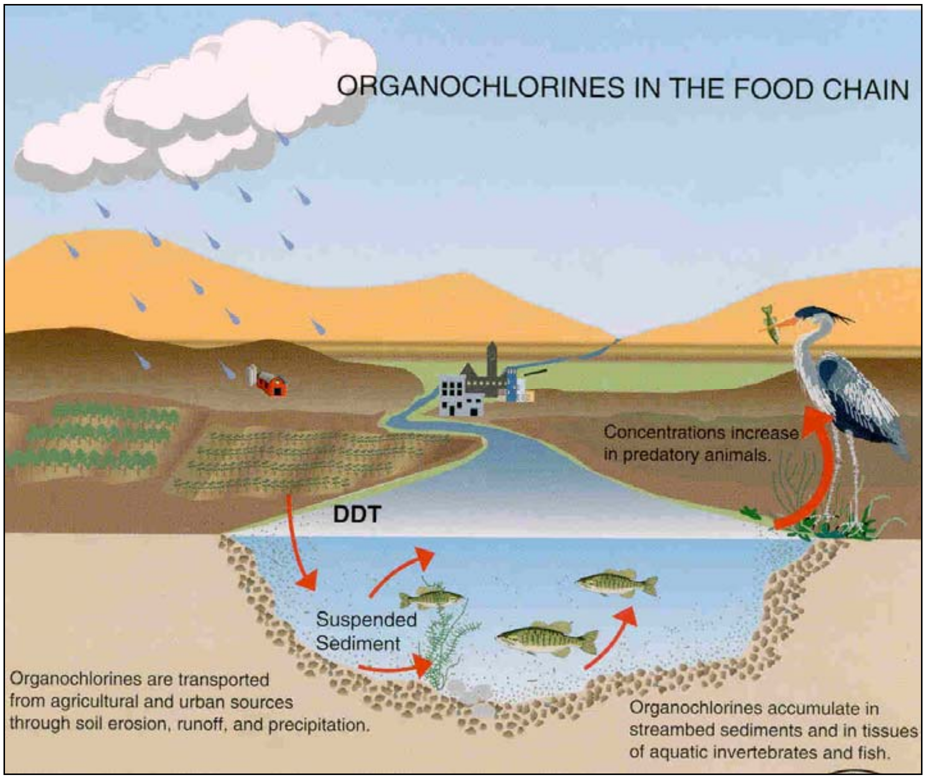

Figure 54. Diagram illustrating the concept of bioaccumulation in the environment (Marret and Ott 1997)

Using the concept of bioaccumulation as a starting point, BAFs specific to the dynamics of the King Hill-C.J. Strike Snake River segment were developed. The King Hill-C.J. Strike BAFs were developed following the methods outlined in the EPA 2000 publication entitled "Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health." Appendix G describes the process by which the bioaccumulation factors for t-DDT and dieldrin were developed.

Using the derived bioaccumulation factors (Appendix G) for t-DDT and dieldrin as the basis, the calculated water column concentrations of t-DDT and dieldrin at C.J. Strike Reservoir are 0.0004 µg/L and 0.0001µg/L, respectively. Table 25 shows the calculated concentrations in comparison to the aquatic life and contact recreation water column targets outlined above.

Table 25. Calculated t-DDT and dieldrin water column concentrations in C.J. Strike Reservoir

Pesticide	Beneficial Use[1]	Calculated Concentration (µg/L)	Target Concentration (µg/L)
t-DDT	CWAL	0.00044	0.001
t-DDT	DWS	0.00044	0.00059
Dieldrin	CWAL	0.00011	0.0019
Dieldrin	DWS	0.00011	0.00014

[1] CWAL: cold water aquatic life, DWS: domestic water supply

In addition to the calculated values shown above, Idaho Power Company and DEQ collected follow-up DDT and dieldrin samples during the summer of 2004:

- Idaho Power Company collected samples from the Snake River at King Hill and Loveridge Bridge. Both samples were none detect for both constituents.
- DEQ collected samples from the Snake River at King Hill and Loveridge Bridge and from C.J. Strike Reservoir at river miles 497 (lacustrine zone), 506 (transitional zone), and river mile 4.0 of the Bruneau Arm. Again, all samples were non-detect for both constituents.

The intent of these sampling efforts was two-fold. First, both entities wanted to verify that DDT and dieldrin were no longer detectable in the water column. Second, since the BAF analysis described earlier uses Loveridge Bridge as the surrogate location for the entire reservoir, DEQ wanted to ensure that DDT and dieldrin were indeed undetectable in the reservoir.

Recommendations for DDT and Dieldrin

The data presented in Table 25 and recently collected data show that the calculated t-DDT and dieldrin water column concentrations do not exceed the target concentrations for cold water aquatic life or domestic water supply beneficial uses. DEQ does not recommend developing a TMDL for these pesticides. However, the data presented in Table 23 and in Appendix G do show that recently collected fish tissue samples still contain measurable levels of DDT. These fish pose a potential health threat to predatory wildlife. Most at risk are predators of larger fish that have lived for several years, such as bald and golden eagles, both of which inhabit areas of the C.J. Strike Reservoir vicinity (Idaho Power Company 1998.)

Since DDT and dieldrin were banned from use in 1973 and 1987, respectively, there should be no new discharges of either compound. However, as shown above, the compounds are still detectable in a variety of media, particularly DDT. Again, this is likely due to their biopersistence (long half-life).

Assuming that no new discharges of DDT and dieldrin are occurring, other measures can be taken to decrease the transport potential of sediment bound legacy pesticides into the Snake River and C.J. Strike Reservoir. Unfortunately, the direct removal of pesticides deposited in sediments is not feasible in the watershed. Any potential sources of legacy pesticides in the area are likely to be diffuse in nature and do not stem from a discrete source but, rather, from historical application on agricultural lands or deposition from surface water transport. Removal of the sediments and organic material associated with these compounds would potentially result in degradation of other habitat parameters through sediment removal and disturbance.

However, while direct removal of pesticide pollutants is not feasible, management practices targeted to reduce further sediment transport to surface water systems will also have the side effect of reducing any sediment bound pesticides. Pesticide transport and deposition are, in most cases, directly correlated with the transport and deposition of sediment and organic matter (Clark and Maret, 1998; Maret, 1995; Maret and Ott, 1997; Rinella et al., 1994). Reductions in the amount of these materials entering the system will likely result in reduction of pesticide pollutant transport and loading to the system. Reduction of such transport will be directly linked to the sediment reduction measures identified within this and other related TMDLs in the Snake River Basin.

Additional Pesticides Analysis

At the request of the King Hill-C.J. Strike watershed advisory group, an evaluation of several additional pesticides was performed. This analysis was performed if two criteria were met:

- water column concentration data were available
- a standard for that given pesticide existed within the *Idaho Water Quality Standards and Water Treatment Requirements*

Based on meeting both of these criteria, additional analyses were performed for aldrin, endrin, heptachlor, heptachlor epoxide, lindane, alpha-HCH, and dacthal. After compiling the data, two distinct data sets were identified. Aldrin, endrin, heptachlor, heptachlor epoxide, and lindane data were available for the period 1965-1971, and alpha-HCH, dacthal, and lindane data were available for the period 1994-2002. Unfortunately, no data were available for the period between 1971 and 1994.

Tables 26 and 27 show the results of comparing the mean concentration for each pesticide for the period of record to the applicable water quality standard for the protection of cold water aquatic life and domestic water supply. It should be noted that these data were collected at King Hill. As such, they do not represent the most desirable data for determining beneficial use support status in C.J. Strike Reservoir. However, the data do allow for the best available analysis of Snake River conditions within the King Hill area and offer the additional insight requested by the watershed advisory group.

Table 26. Mean pesticide concentration at King Hill for the period of record as compared to the applicable water quality standard, 1965-1971 data

Pesticide	Beneficial Use[1]	Calculated Mean Concentration (µg/L)	Target Concentration (µg/L)
Aldrin	CWAL	0.00063	None Available
Aldrin	DWS	0.00063	0.00013
Endrin	CWAL	0.00048	0.0023
Endrin	DWS	0.00048	0.76
Heptachlor	CWAL	0.0014	0.0038
Heptachlor	DWS	0.0014	0.00021
Heptachlor epoxide[2]	CWAL	0.00016	0.0038
Heptachlor epoxide[2]	DWS	0.00016	0.0001
Lindane	CWAL	0.0027	0.08
Lindane	DWS	0.0027	0.019

[1] CWAL: cold water aquatic life, DWS: domestic water supply
[2] Oxidized form of Heptachlor

Table 27. Mean pesticide concentration at King Hill for the period of record as compared to the applicable water quality standard, 1994-2002 data

Pesticide	Beneficial Use[1]	Calculated Mean Concentration (µg/L)	Target Concentration (µg/L)
Alpha-HCH[2]	CWAL	0.0014	None Available
Alpha-HCH[2]	DWS	0.0014	0.0039
Dacthal	CWAL	0.0011	None Available
Dacthal	DWS	0.0011	70
Lindane	CWAL	0.0020	0.08
Lindane	DWS	0.0020	0.019

[1] CWAL: cold water aquatic life, DWS: domestic water supply
[2] Photochlorinated form of Benzene

The data presented in Table 26 show that the mean aldrin, heptachlor, and heptachlor epoxide concentrations for the 1965-1971 POR exceed the current standards for domestic water supply. The aquatic life standard is not exceeded with these or any of the other pesticides (endrin or lindane). While not shown in Table 26, it is important to note that the values causing the mean concentrations to exceed the aldrin, heptachlor, and heptachlor epoxide standards all occurred in 1966 and 1967. There were no exceedances in 1965 or 1968-1971. Apparently, some factor or combination of factors caused an acute spike in the concentrations during 1966 and 1967 because from 1968 to 1971 there were no exceedances.

Table 27 shows that the mean alpha-HCH, dacthal, and lindane concentrations for the 1994-2002 POR are all below the current standards for domestic water supply and/or cold water aquatic life.

Recommendations for the Additional Pesticides

Of the available data for all years, only the aldrin, heptachlor and heptachlor epoxide data for the period 1966 and 1967 show exceedances of the current standards. Since the 1968-1971 data do not show exceedances because aldrin has since been banned from use and because heptachlor is no longer used for agricultural purposes, DEQ does not recommend developing a TMDL for these pesticides.

Pesticides Loading Analysis Summary

The data presented in Tables 24 and 25 and recently collected data show that the t-DDT and dieldrin concentrations in C.J. Strike Reservoir do not exceed the target concentrations for cold water aquatic life or domestic water supply beneficial uses. In addition, Tables 26 and 27 show that aldrin, endrin, heptachlor, heptachlor epoxide, lindane, alpha-HCH, and dacthal do not exceed current standards in the Snake River near King Hill. Based on these analyses, DEQ does not recommend developing a TMDL for pesticides and recommends de-listing pesticides as a pollutant of concern from the next available §303(d) list.

Nutrient Loading Analysis

C.J. Strike Reservoir is §303(d) listed for excess nutrient. The *Idaho Water Quality Standards and Wastewater Treatment Requirements* (IDAPA 58.01.02) designate beneficial uses for the C.J. Strike Reservoir, which include cold water aquatic life. To determine impairment of water quality by excess nutrients, this analysis uses levels of dissolved oxygen as an indicator of water quality. Excess nutrients and dissolved oxygen are inversely correlated: when excess nutrients are high, dissolved oxygen is low. Data from the Idaho Power Company show that Idaho's water quality standard for dissolved oxygen is violated. An analysis of the Idaho Power Company data will demonstrate the water quality issues in the reservoir relating to excess nutrients.

The presence of a reservoir is a human disturbance, so water quality cannot be completely restored to the condition of the river before impoundment. However, the symptoms of water quality impairment can be managed. Reservoirs need management and protection because they are subject to the same effects of silt, organic matter, and nutrient loading as lakes. On the average, nutrient and sediment loads are much higher for reservoirs than lakes. In general, reservoirs are at the bottom of a watershed receiving the inflow of more tributaries than lakes, which are generally central in a watershed and in a symmetrical drainage. Nutrient and sediment loads are, on the average, much higher for reservoirs and this material may have undergone a far longer period of in-stream processing than for material loaded to natural lakes. In addition, reservoir watersheds are generally nearly an order of magnitude greater than the average watershed of a lake, which accounts for the higher areal load of reservoirs. Water often enters lakes via smaller streams that are likely to traverse wetland or littoral areas, which filter pollutants, whereas reservoir inflows often have characteristics of a major river for large distances into the reservoir, allowing little opportunity for pollutant filtration (Thornton 1990).

Characteristics of Reservoir Zonation

Reservoirs combine qualities of both rivers and lakes, separating into zones called riverine, transitional, and lacustrine (lake-like), according to shape of the basin and velocity of streamflow (Figure 55). Table 28 lists the main differences between the reservoir zones (Kimmel and Groeger 1984).

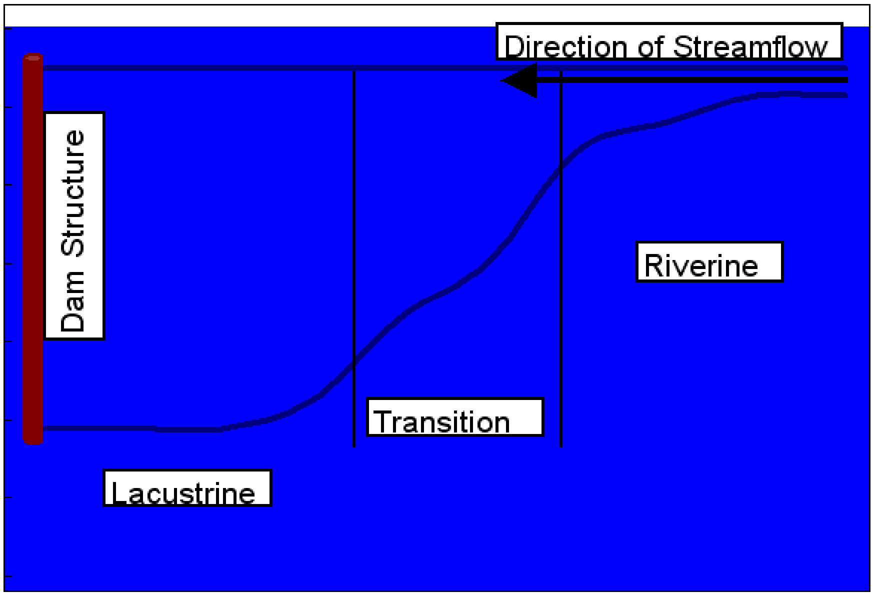

Figure 55. Example reservoir zones

Table 28. Defining characteristics of reservoir zones

Riverine Zone	Transitional Zone	Lacustrine Zone
Narrow -basin	Broader, deeper basin	Broad, deep, lake-like
High streamflow	Reduced streamflow	Little streamflow
High suspended solids, low light	Lower suspended solids, more light	Clearer
High nutrients, advective supply	Advective nutrient supply reduced	Internal nutrient recycling, low nutrients
Light limited photosynthesis	High photosynthesis	Nutrient limited photosynthesis
Algal cell loss by sedimentation	Algal cell loss by sedimentation, grazing	Algal cell loss by grazing
Organic matter supply allochthonous	Intermediate	Organic matter supply autochthonous
More eutrophic	Intermediate	More oligotrophic

The zones control the abundance and metabolism of algae and the way the system processes nutrients. The riverine zone is dominated by flow and mixing. In the rapid flushing conditions of the riverine zone, algal abundance is more dependent on flushing than on nutrient concentrations. In the transitional zone, the inflow velocity slows, rapid sedimentation begins, and water clarity increases. The lacustrine zone has thermal stratification and a higher probability of nutrient limitation of algal growth (Wetzel 2001).

Characteristics of Reservoir Stratification
In the lacustrine zone of deep reservoirs, surface waters warm in the summer while bottom waters remain cool. Cold water is denser than warm water, so the surface waters and bottom waters do not mix. The surface waters (epilimnion) continue to be mixed by wind, while the bottom waters (hypolimnion) do not mix with the upper layers of water (Figure 56). The middle layer (*metalimnion* or *thermocline*) is the area with the most rapid temperature change.

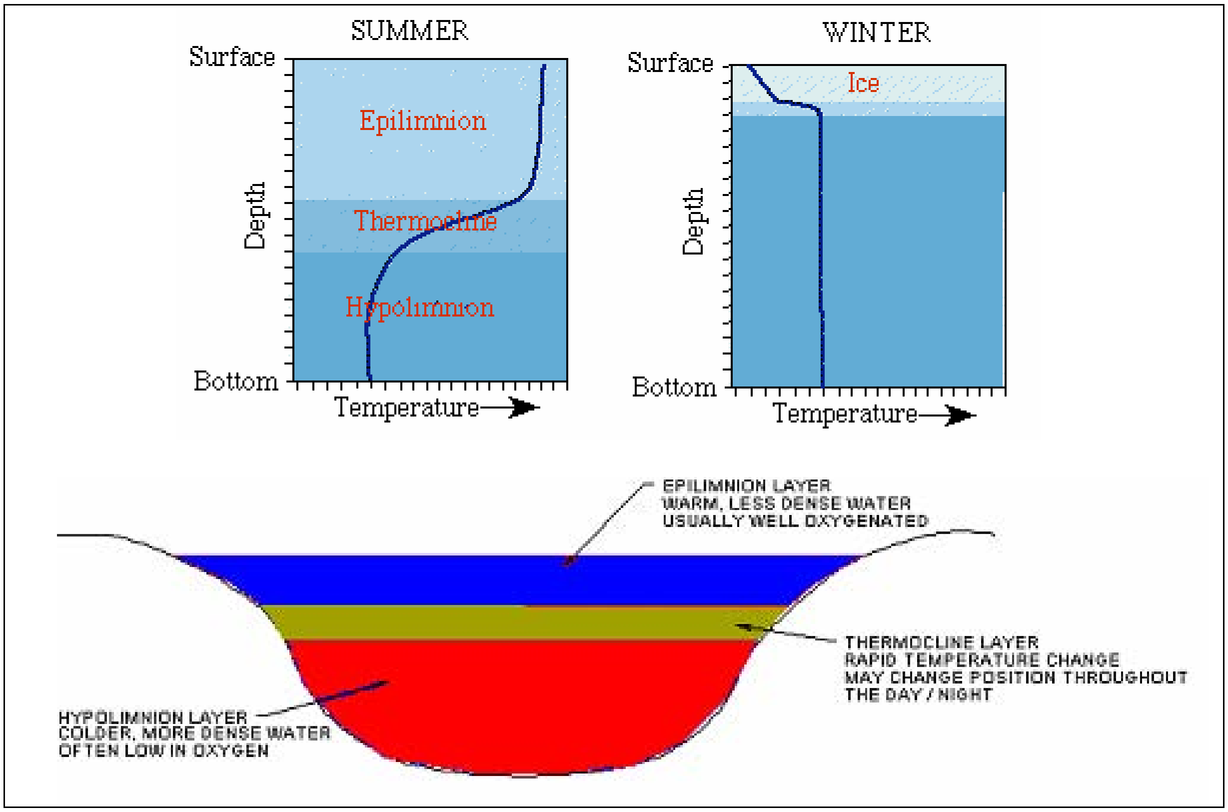

Figure 56. Depictions of a stratified lacustrine zone

This thermal stratification generally remains in the lacustrine zone until cooler air temperatures in the fall cool the surface waters sufficiently to cause the stratified layers to turn over and mix thoroughly. Stratification is the main driver of the physical, chemical, and biological interactions of a lake. Features of strata are given in Table 29 (Wetzel 2001).

Table 29. Defining characteristics of reservoir stratification layers

Epilimnion	Metalimnion	Hypolimnion
Warm isothermic	Warm to cold thermal discontinuity	Cold isothermic
Abundant Oxygen	Variable oxygen	Oxygen low or absent, increased concentrations of soluble forms of contaminants and nutrients
Warm water fishery	Mixed fishery	Coldwater fishery if oxygen adequate

Effects of Excess Nutrients in Reservoirs

Nutrients, including nitrogen and phosphorus, support plant growth and the food web. Although nutrients are necessary to support life in aquatic ecosystems, excess nutrients are detrimental to water quality, causing more algal and plant growth than can be consumed in the food web of the reservoir. Excess algal growth, causing slime and choked plant growth, creates problems for many beneficial uses of water resources, including the following:

Aquatic life

- Increased pH, changing the animal community composition
- Depleted dissolved oxygen, adversely affecting animal populations and ultimately causing fish kills

Drinking water

- Gives an unpleasant taste and smell to the water
- Increases costs of treating drinking water

Recreation and aesthetic enjoyment

- Reduces water clarity
- Makes swimming conditions unpleasant
- Causes objectionable odors
- Interferes with boating
- Creates a polluted appearance

Trophic state refers to the overall level of nutrients and related algal and plant growth in the system. *Eutrophication* is the artificial increase in the trophic state of a system caused by human activities, such as overuse of fertilizers and wastewater input to surface waters. The four major trophic classes include (Natural Resources Conservation Service 1999) the following:

- Oligotrophic – systems that have low supplies of nutrients; poorly nourished
- Mesotrophic – systems with intermediate nutrient supplies
- Eutrophic – systems that have a large supply of nutrients; well nourished
- Hypertrophic – systems that have excessively large supplies of nutrients.

The shape of a basin greatly influences the effectiveness of excess nutrients. Shallow and broad stream channels allow more margins for rooted plants, which creates more leaf and sediment surfaces to harbor algae; all of the biological activities in these areas create internal nutrient loading. Productivity is negatively correlated with mean depth so deeper reservoirs have a greater capacity to receive excess nutrients without increasing the biomass of plants and algae (Cooke 1993).

C.J. Strike Reservoir Nutrient Assessment

For the C.J. Strike Reservoir, DEQ assessed water quality from river mile 510 downstream to river mile 494 at the dam (Figure 57). Since 1995 is the year with the most extensive Idaho Power Company data, and the Snake River stream flow was near average, data from March through September 1995 is used in this reservoir water quality assessment.

The size and shape of C.J. Strike Reservoir, and the extent of water quality data, are important to this assessment. Data for the reservoir from river mile (RM) 510 to 494 exists at monitoring stations, including RM 494.5, 495.3, 498, 500, 502, 504, 506, 508, and 510. Water quality data, including temperature, conductivity, pH, dissolved oxygen, phosphorus, nitrogen, and chlorophyll-a were measured at depths of 0.3, 3, 5, 10, 15, 20, and 25 meters. Most frequently, temperature, conductivity, pH, and dissolved oxygen were monitored every two weeks, and the other components were monitored every four weeks.

Monitoring at various depths throughout the reservoir, from March through September, reveals the variability of the water quality at different locations, depths, and times of the year. Figure 58 is a grid representing the bathymetry of the reservoir; each grid cell is two meters deep, the number inside each grid cell is the width of the reservoir at that point, and the length of each grid cell is listed on the fourth row down the table. In this assessment, all of the dimensions of surface area, volume, and depth are calculated from this grid. This is also the grid used by Idaho Power Company consultants to model water quality in the reservoir with the CE-QUAL-W2 (Cole and Wells 2003) model.

C.J. Strike Reservoir Stratification

The *Osgood Index* is a screening level indicator of the overall mixing capacity of a reservoir or lake. The Osgood Index equals the mean depth (z) divided by the square root of the surface area (A) of the reservoir ($z/A^{0.5}$). A low number is a shallow, broad reservoir that is readily mixed by wind. Higher numbers indicate more resistance to mixing. The C.J. Strike Reservoir from river mile 502 to 494 has a surface area of 8,519,183 meters^2 and a mean depth of 27.82 meters. The Osgood Index of C.J. Strike Reservoir is therefore $27.82/8{,}519{,}183^{0.5}$ = 0.01. An Osgood Index of less than 6.0 would indicate that the system is a deep, stratified lake, but with some transfer of phosphorus from the hypolimnion to the upper waters (Natural Resources Conservation Center 1999).

A stratified deep lake with some hypolimnetic phosphorus transfer is moderately sensitive to increased phosphorus loading, but relatively insensitive to decreased phosphorus loading. That is, it will take a long time for such a system to show a response to a decreased phosphorus load. Large phosphorus concentrations build up in the hypolimnetic sediments and only a limited amount transfers up to the metalimnion (Natural Resources Conservation Center 1999). Although the Osgood index is a screening tool, plotting the temperature data for C.J. Strike Reservoir also shows a stratified system. Figure 59 shows how the temperature profile at RM 494.5 becomes increasingly stratified from May through September and then becomes more isothermal as the weather cools in October.

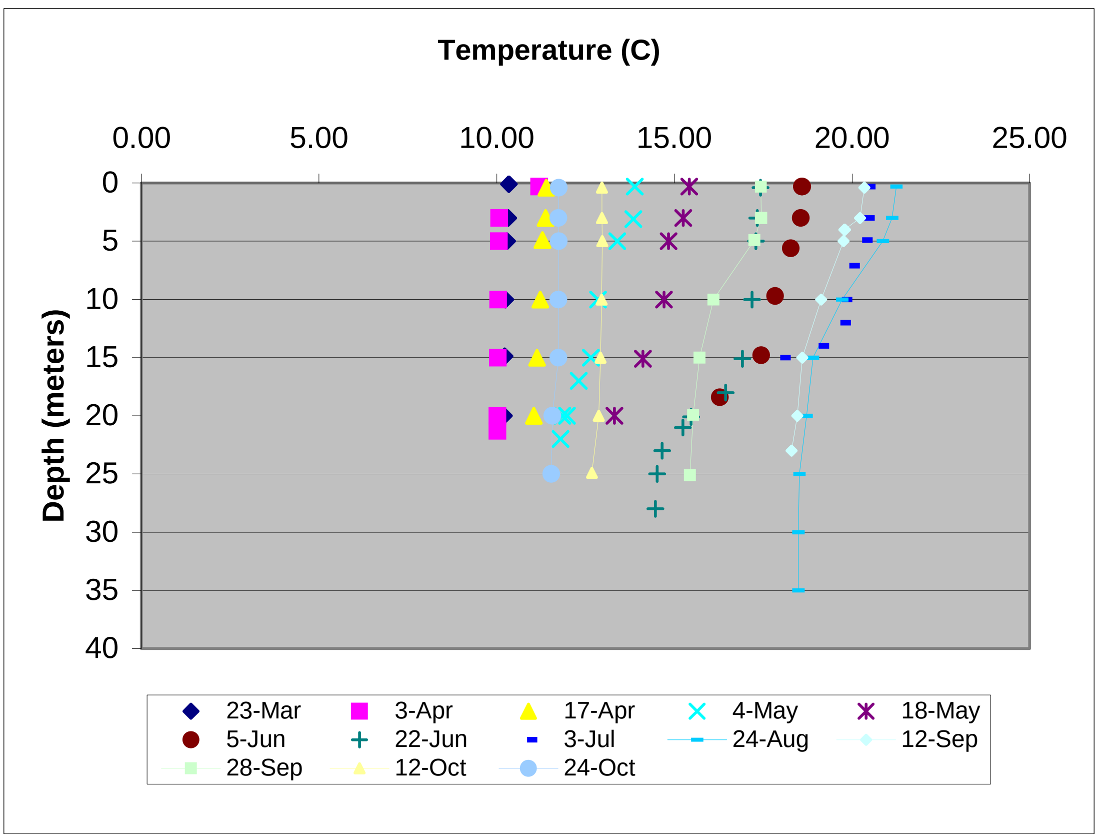

Figure 59. 1995 temperature profiles at river mile 494.5

Orthophosphorus (OP) is the biologically-available form of phosphorus that is dissolved and ready to be consumed and metabolized by algae. Therefore, it is a stronger indicator of eutrophication potential than evaluating total phosphorus for this purpose. The OP data shows that the reservoir is stratified and resistant to mixing because the deepest measurements consistently have the largest OP amounts. The OP is migrating out of the sediment to the hypolimion for a very high internal loading. However, it is trapped by the stratification, otherwise OP would mix vertically into the photic zone and have a greater effect on algal growth. This example shows how strongly water quality is interrelated with the physical structure of the reservoir. In this instance, stratification affects nutrient migration and availability for algal growth.

Plotting the orthophosporus data also somewhat supports the Osgood prediction of reservoir type but infers a stronger stratification (Figure 60).

C.J. Strike Reservoir Zonation

C.J. Strike reservoir shows distinctive zones, according to the average horizontal velocity throughout the reservoir (Figure 61). The fastest moving water is from RM 520 to 513, where a sharp drop occurs. This is the riverine portion of the reservoir. From RM 513 to 502, velocity fluctuates but shows a general slowing trend in the transition zone. The lacustrine zone is from RM 502 to 494 where the velocities are the slowest. The plan view of the reservoir in Figure 57 and the side view of the reservoir in Figure 58 demonstrate how the shape of the channel affects slowing, with the reach from RM 502 to 494 being the broadest and deepest part of the reservoir.

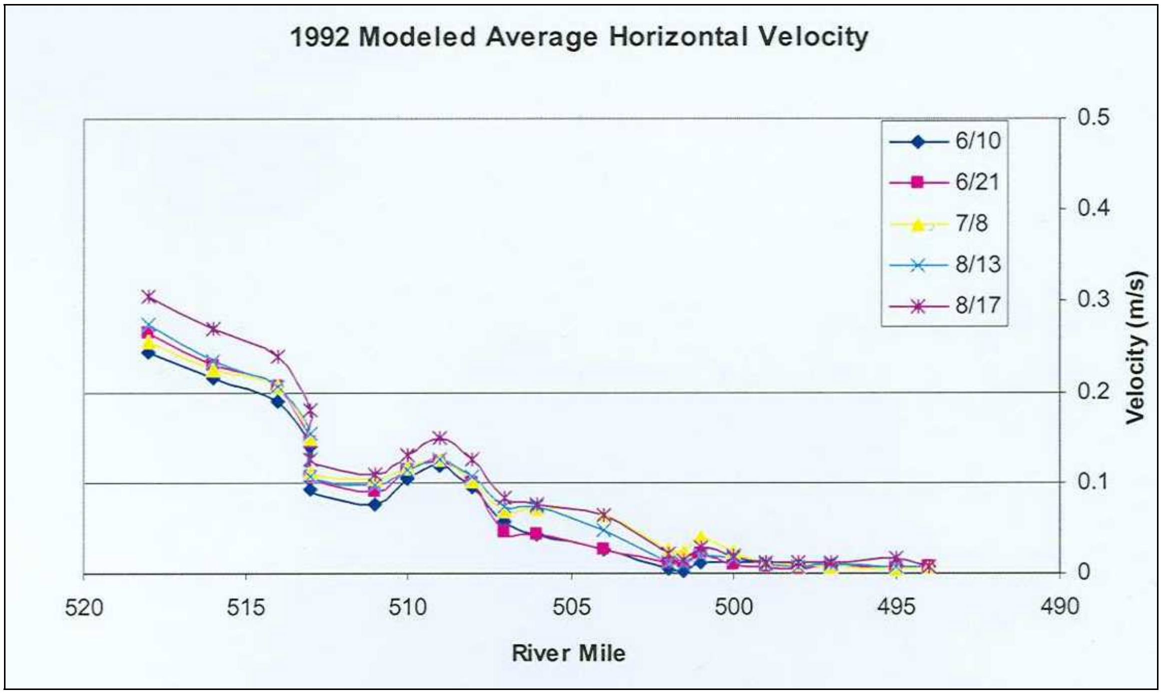

Figure 61. Average horizontal velocity by river mile in C.J Strike Reservoir, 1992 data.

Nutrient Characteristics

When a nutrient, generally nitrogen or phosphorus, is not available in sufficient quantities to support plant growth, it is termed the limiting nutrient To determine the limiting nutrient, most aquatic plants contain 7.2 times as much nitrogen as phosphorus. Therefore, if the N:P ratio is less than 7.2:1, nitrogen is limiting. If the ratio is higher than 7.2:1, phosphorus is limiting. In the Idaho Power Company license application for a Federal Energy Regulatory Commission license renewal, a water quality report describes the C.J. Strike reservoir as a phosphorus limited system (Idaho Power Company 1998). When excess quantities of a limiting nutrient are added to a system, plant and algae populations (total organic matter) are elevated to a nuisance polluting level.

Also, the waters nearest the reservoir do not show orthophosphorus, indicating that phosphorus is the limiting nutrient. Referring to Figure 60, the data points below the X-axis are the non-detect numbers. This indicates that the reservoir is not so enriched to the point that there is always excess phosphorus. The downward spike in orthophosphate shows that phosphorus is not overly enriched. The high volume and depth of the reservoir help in this assimilative capacity. The residence time is not so high that orthophosphate never moves.

Trophic Status

Several classification systems have been developed to classify the trophic status of lakes and reservoirs. The Carlson Trophic Index and Vollenweider classification system, described in Table 30, are two general methods to classify lakes and reservoirs as oligotrophic, mesotrophic, eutrophic, or hypertrophic (EPA 1999).

Table 30. Trophic status classification systems

Carlson Trophic Status Index (TSI) for biomass-related measures		
TSI (Chlorophyll-a) = 30.6 + 9.81 ln[1] (Chl)	TSI < 40 =	Oligotrophic
TSI (Total Phosphorus) = 4.15 + 14.42 ln (TP)	35<TSI<45=	Mesotrophic
TSI (Secchi Depth) = 60 – 14.41 ln (SD)	TSI > 45 =	Eutrophic
TSI (Total Nitrogen) = 54.45 + 14.43 ln (TN)	TSI > 60 =	Hypertrophic

Vollenweider Trophic status classification						
Water Quality Parameter	Oligotrophic		Mesotrophic		Eutrophic	
	Mean	Range	Mean	Range	Mean	Range
Total phosphorus (µg/l)	8	3-18	27	11-96	84	16-390
Total nitrogen (µg/l)	660	310-1,600	750	360-1,400	1900	390-6,100
Chlorophyll a (µg/l)	1.7	0.3-4.5	4.7	3-11	14	2.7-78
Peak chlorophyll a (µg/l)	4.2	1.3-11	16	5-50	43	10-280
Secchi depth (m)	9.9	5.4-28	4.2	1.5-8.1	2.4	0.8-7.0

[1]ln: natural log

Since phosphorus is the limiting nutrient, its concentration will be most indicative of the trophic status of the reservoir. When all of the phosphorus concentration measurements in the reservoir are weighted, according to the volume of the reservoir, the volumetrically-weighted average total phosphorus concentration is 0.11 mg/l (110 µg/L). By the Carlson trophic status index, C.J. Strike is hypertrophic, and by the Vollenweider classification, it is eutrophic.

Dissolved Oxygen

In this particular eutrophic to hypertrophic system, the elevated phosphorus levels contribute to excess organic matter, which in turn contributes to a depletion of dissolved oxygen, which is detrimental to cold water aquatic life. Temperature and dissolved oxygen are important to evaluating water quality, as their range throughout the reservoir and throughout the year equate with habitat availability. Available habitat is diminished when elevated nutrient levels deplete the levels of dissolved oxygen to the point that aquatic life can no longer survive. Idaho's water quality standards at IDAPA 58.01.02.250 define the dissolved oxygen requirements for cold water aquatic life as 6.0 mg/l at all times, except in the bottom-most portion of lakes and reservoirs:

In lakes and reservoirs, this standard does not apply to:

- The bottom twenty percent (20%) of water depth in natural lakes and reservoirs where depths are thirty-five (35) meters or less
- The bottom seven (7) meters of water depth in natural lakes and reservoirs where depths are greater than thirty-five (35) meters.
- Those waters of the hypolimnion in stratified lakes and reservoirs.

The hypolimnion, which is excluded from meeting this dissolved oxygen standard in a stratified system, is defined in the Idaho water quality as a zone with a rapid temperature drop of 1°C or more. It if further defined as:

. . . the deepest zone in a thermally-stratified body of water. It is fairly uniform in temperature and lies beneath a zone of water which exhibits a rapid temperature drop with depth of at least one (1) degree C per meter.

Since aquatic life is the most sensitive designated use in C.J. Strike Reservoir, the indicator of water quality is dissolved oxygen, and the desired water quality target is to be above 6 mg/l at all times, except in the excluded bottommost portion of the reservoir.

In 1995, Idaho Power Company collected vertical profile measurements for dissolved oxygen and temperature in the C.J. Strike Reservoir at the following river miles: 494.5, 495.3, 498, 500, 502, 504, 506, 508, and 510 (see Figure 57 for locations). These vertical temperature profiles help show whether the water column is isothermal or stratified. DEQ analyzed the vertical profile measurements to identify violations of Idaho's water quality standards for dissolved oxygen. The difference in temperature between the topmost and bottommost water column measurements identifies whether the water column is isothermal or stratified. If the difference in temperature is 3°C or greater in collected data, the water column is evaluated as stratified; if the difference is less than 3°C, the water column is evaluated as isothermal. Using 3°C as the variance between the surface and bottom reservoir temperatures is a general limnological guideline (Wetzel 2001) as well as a standard of DEQ's trophic monitoring plan for lakes and reservoirs (not published).

If the reservoir is stratified on a given monitoring date at a given river mile, then the hypolimnion is identified as the area of the water column below which a temperature drop of greater than 1°C per meter is sustained. The hypolimnion is excluded from meeting the 6.0

mg/l dissolved oxygen standard. Any waters of the metalimnion or epilimnion, with a dissolved oxygen concentration of 6 mg/l or less, show a violation of the water quality standard. If there is no zone with a temperature drop greater than 1°C per meter, the water column will be evaluated as isothermal. The temperature and dissolved oxygen measurements are linearly interpolated for each meter of depth where necessary to identify the metalimnion.

If the reservoir is isothermal, different qualifications to the standard apply. If the reservoir is deeper than 35 meters, which occurs only at river mile 494.5, then the bottom 7 meters of the reservoir are excluded from the dissolved oxygen standard. If the reservoir is less than or equal to 35 meters deep, then the bottom 20% of the total depth is excluded from meeting the dissolved oxygen standard. The flow chart in Figure 62 summarizes the analysis performed on the temperature and dissolved oxygen measurements in C.J. Strike Reservoir.

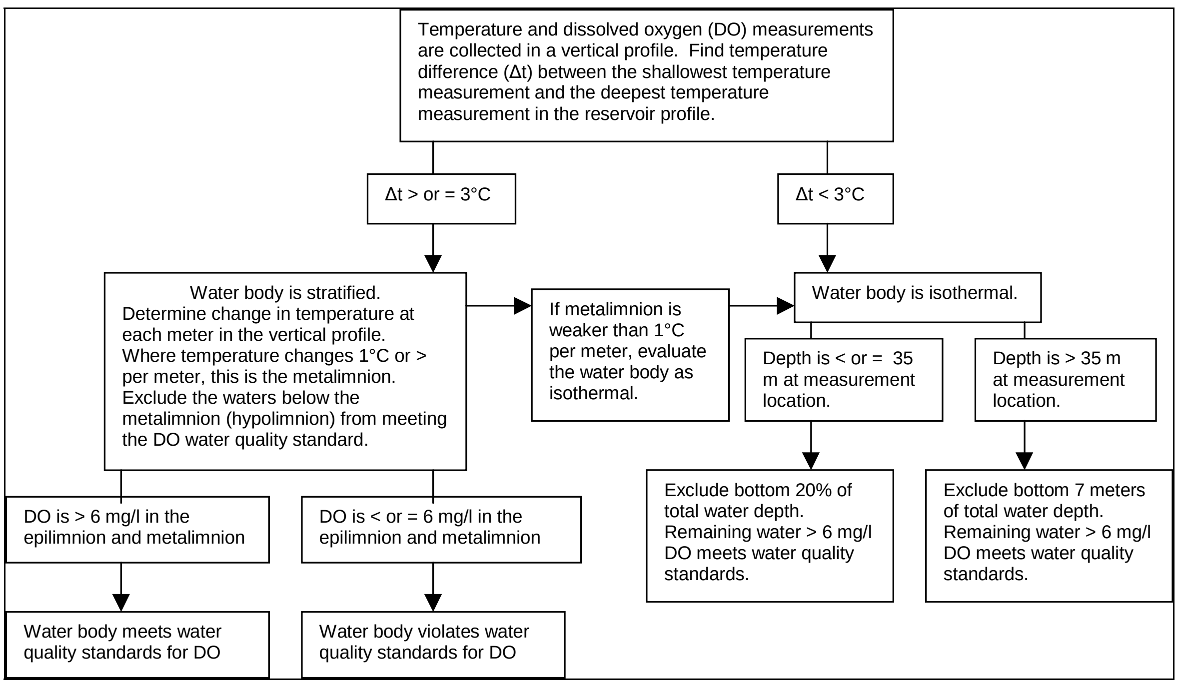

Figure 62. Summary of dissolved oxygen water quality standard application

Examples of how the Idaho Power Company dissolved oxygen data were compared to the Idaho Water Quality Standards and Wastewater Treatment Requirements can be found in Appendix K.

Results of analyzing the 1995 Idaho Power vertical profile measurements for dissolved oxygen and temperature in the C.J. Strike Reservoir show depleted dissolved oxygen measurements, which violate Idaho's water quality standards. In summary, the dissolved oxygen depletion problems occurred on the following dates and river miles:

- June 5 through September 12 at river mile 494.5
- May 18 through September 12 at river mile 495.3
- May 18 through August 24 at river mile 498
- May 18 through August 24 at river mile 500
- August 24 at river mile 502

Specific dissolved oxygen violations are shown in Figure 63 and listed in Table 31. There are 69 total dissolved oxygen violations, 64 of which (93%) are between depths of 10m to 25m.

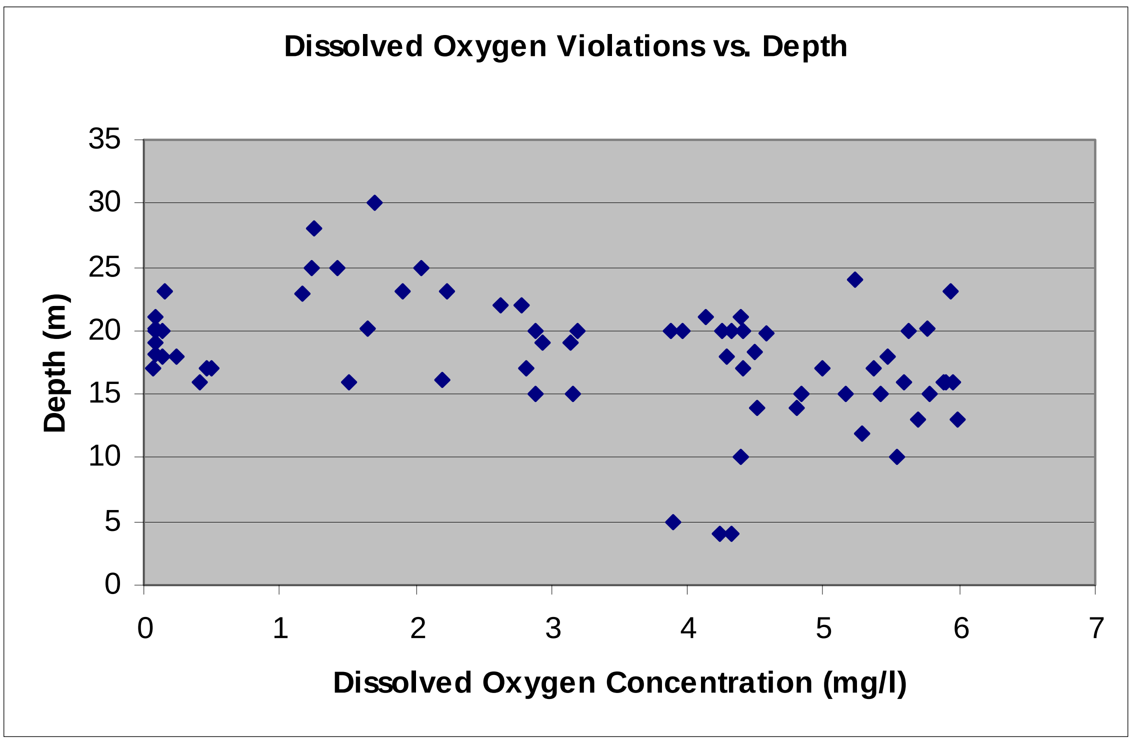

Figure 63. C.J. Strike Reservoir dissolved oxygen measurements below 6.0 mg/L vs. depth

Table 31. Violation of the 6.0 mg/L water quality standard in C.J. Strike Reservoir, based on 1995 data

Date	River Mile	DO[1]	Depth (m)	Date	River Mile	DO	Depth (m)
9/12	494.5	4.32	4	7/3	495.3	2.93	19
9/12	494.5	4.23	4	7/19	500	0.08	19
9/12	494.5	3.89	5	6/5	495.3	4.58	19.7
9/12	494.5	5.55	10	7/3	498	4.41	19.9
9/12	495.3	4.39	10	6/22	495.3	4.26	20
9/12	495.3	5.29	12	6/22	498	5.63	20
7/19	498	5.7	13	7/3	495.3	2.88	20
7/19	495.3	5.98	13.1	7/19	495.3	0.13	20
7/19	495.3	4.52	13.9	7/19	500	0.08	20
7/19	498	4.81	14	8/24	494.5	3.88	20
7/3	494.5	5.43	15	8/24	495.3	4.33	20
7/19	495.3	3.16	15	8/24	498	3.19	20
7/19	498	2.88	15	8/24	500	3.96	20
8/24	494.5	4.84	15	5/18	495.3	5.76	20.1
8/24	495.3	5.17	15	6/22	494.5	1.64	20.1
8/24	498	5.78	15	7/19	498	0.09	20.1
7/3	500	5.96	15.9	5/18	498	4.39	21
7/3	495.3	5.59	16	6/22	494.5	4.13	21
7/3	498	5.88	16	7/19	500	0.09	21.1
7/19	498	0.41	16	6/22	495.3	2.78	22
7/19	500	1.51	16	8/24	495.3	2.62	22
8/24	502	5.9	16	7/3	495.3	1.16	22.9
7/19	495.3	2.2	16.1	5/18	500	5.93	23
7/3	498	5	17	6/22	494.5	2.23	23
7/19	498	0.07	17	6/22	495.3	1.91	23
7/19	500	0.46	17	7/19	495.3	0.15	23
8/24	498	5.37	17	5/18	500	5.24	24
8/24	500	4.41	17	6/22	494.5	1.43	25
8/24	502	2.82	17	6/22	495.3	1.24	25
7/19	495.3	0.5	17.1	8/24	494.5	2.04	25
6/22	495.3	5.48	18	6/22	494.5	1.25	28
7/3	495.3	4.29	18	8/24	494.5	1.69	30
7/19	495.3	0.14	18	--	--	--	--
7/19	500	0.24	18	--	--	--	--
7/19	498	0.08	18.1	--	--	--	--
6/5	494.5	4.49	18.4	--	--	--	--
6/5	498	3.14	19	--	--	--	--

[1] Dissolved Oxygen

These violations of the dissolved oxygen water quality standard show that habitat availability for aquatic life is diminished during these episodes. To help visualize the extent of the problem of dissolved oxygen depletion, Figure 64 shows a cross-sectional view of the reservoir when violations occur. The violations mostly occur between depths of 10 and 25 meters up to river mile 504.

In the transition zone from RM 510 to 504 (blue grid) and also in the surface layers of the rest of the reservoir from the surface to a depth of ten meters (pink grid), there are no dissolved oxygen depletion problems. In the bottom layers of the reservoir from a depth of 25 to 30 meters (yellow grid), the water becomes very depleted of oxygen, but the bottommost portion of the reservoir is excluded from meeting the 6 mg/l standard, because this oxygen depletion is a natural occurrence in very deep lakes and reservoirs.

From RM		494	495	496	497	498	499	499	500	500	501	501	502	503	504	505	506	506	507	508	509
To RM		495	496	497	498	499	499	500	500	501	501	502	503	504	505	506	506	507	508	509	510
Segment	30	29	28	24	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10
Length	0.0	2414.0	1609.3	1609.3	841.2	847.3	911.4	992.1	681.2	940.3	1040.9	1152.1	1444.8	1281.7	1249.7	1543.8	752.9	888.5	1609.3	1609.3	1609.3
Depth (m)	Width (m)																				
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	875	885	598	751	622	488	473	263	229	383	1002	335	310	198	172	285	388	269	204	264
4	0	853	856	594	698	618	482	461	256	221	375	977	308	303	195	168	273	377	231	185	223
6	0	819	803	584	640	607	465	432	245	208	353	951	273	291	185	158	252	342	192	153	177
8	0	789	746	571	558	586	448	393	233	194	326	921	243	277	172	145	210	223	151	90	20
10	0	763	684	557	491	563	433	351	220	181	298	890	219	250	156	132	127	50	50	20	0
12	0	735	623	537	442	535	415	304	203	168	267	852	198	188	134	118	90	30	20	0	0
14	0	701	553	509	392	499	381	251	183	110	225	749	175	150	116	98	50	20	0	0	0
16	0	662	469	475	248	461	305	201	164	90	193	314	150	110	100	73	30	0	0	0	0
18	0	610	401	432	294	429	237	169	146	70	173	204	112	50	20	30	0	0	0	0	0
20	0	541	336	375	227	388	177	145	90	50	50	50	50	20	0	0	0	0	0	0	0
22	0	448	273	313	168	276	134	121	70	40	30	20	20	0	0	0	0	0	0	0	0
24	0	305	217	256	128	130	100	87	50	30	20	0	0	0	0	0	0	0	0	0	0
25	0	203	185	155	96	90	50	50	30	20	0	0	0	0	0	0	0	0	0	0	0
26	0	124	90	90	50	50	30	30	20	0	0	0	0	0	0	0	0	0	0	0	0
28	0	50	50	50	30	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Layer thickness = 2																					

Figure 64. Dissolved oxygen violations in C.J. Strike Reservoir.

The problematic portion of the reservoir lies in the area between 10 and 25 meters deep, from RM 494 to RM 504 (peach grid). This is where almost all (93%) of the dissolved oxygen violations occur. The volume of each of these portions of the reservoir is calculated and shown in Figure 65. The area with most of the dissolved oxygen violations equals over 35% of the volume of the reservoir.

			% total volume
Volume of 0-9.9-503.9 grid =	86479092.4	m^3	50
Volume of 10-24.9-503.9 grid =	62125590	m^3	35.50
Volume of 25-30-503.9 grid =	6785995.6	m^3	4.00
Volume of 504-510 grid =	18329948.8	m^3	10.50
Total volume (m^3)=	173720627	m^3	100.00

Figure 65. Volume of portions of C.J. Strike Reservoir

Bruneau Arm Dissolved Oxygen

The Bruneau River arm of C.J. Strike Reservoir also experiences dissolved oxygen depletion, although not to the extent of the Snake River arm. The Bruneau River arm is shallower than the Snake River arm and is more susceptible to wind related mixing in the upper layers of the reservoir. As a result, the number of dissolved oxygen values below 6.0 mg/L (above the hypolimnion) is minimal (less than 10%) and not numerous enough to constitute a violation of the water quality standards. Table 32 shows the specific dissolved oxygen violations. The location of the river miles can be seen on Figure 57.

Table 32. Violation of the 6.0 mg/L water quality standard in Bruneau River arm of C.J. Strike Reservoir, based on 1995 data

Date	River Mile	DO	Depth (m)
7/19	2	5.05	11
7/19	2	5.12	10
7/19	2	5.12	8
8/24	2	5.91	10
9/12	2	2.5	10
9/12	2	0.67	9
9/12	2	0.84	8
9/12	2	1.85	5.1
9/12	2	4.91	3
9/12	2	1.96	4
8/24	4.3	4.68	7
8/24	4.3	4.95	5.1
9/12	4.3	3.97	8

The Bruneau River arm dissolved oxygen violations shown in Table 32 occurred during the following periods:

- July 19 through September 12 at river mile 2
- August 24 through September 12 at river mile 4.3

The violations at river mile 2 are somewhat non-typical because from Bruneau River mile zero to about river mile 2.5 the Bruneau River arm is susceptible to mixing with the hypolimnetic waters from the lacustrine zone of the Snake River arm. The Bruneau River arm dissolved oxygen data show that in July and August the concentrations in the lower levels of the metalimnion and the hypolimnion are actually higher than the concentrations above those levels. This non-typical phenomenon is due to the influence from the Snake River arm water.

Total Phosphorus

All of the total phosphorus measurements for the reservoir are volumetrically weighted by multiplying the average concentration of each measurement (C(P)) by the percent volume of the grid in which it was measured (%V(P)), and dividing the average of the weighted average concentrations by 100 (AVE{C(P)*%V(P)}/100). When the concentration of all the total phosphorus measurements are weighted according to the volume of these portions of the reservoir, the total volumetrically-weighted concentration of total phosphorus equals 0.11 mg/l (110 µl). Dissolved oxygen is volumetrically weighted in the same manner (Figure 66).

	mg/l of TP weighted avg concentration	kg of TP Weighted average weight
Volumetric Concentration of 0-9.9-503.9 grid=	0.04	7.78
Volumetric Concentration of 10-24.9-503.9 grid=	0.04	7.46
Volumetric Concentration of 25-30-503.9 grid=	0.01	1.02
Volumetric Concentration of 504-510 grid=	0.01	2.02
Total volumetric concentration =	0.11	18.27

	mg/l of DO weighted avg concentration	kg of DO Weighted average weight
Volumetric Concentration of 0-9.9-503.9 grid=	4.88	847.50
Volumetric Concentration of 10-24.9-503.9 grid=	2.36	410.03
Volumetric Concentration of 25-30-503.9 grid=	0.18	30.54
Volumetric Concentration of 504-510 grid=	1.08	186.97
Total volumetric concentration =	8.49	1475.03

Figure 66. Volumetrically-weighted average concentration of total phosphorus and dissolved oxygen.

When all of the volumetrically-weighted average concentrations of each grid were regressed for total phosphorus versus dissolved oxygen, the pink and blue grids showed no correlation between phosphorus and oxygen. This was expected since the transition zone still has some high and fluctuating horizontal velocities (see back to Figure 61), which mix and oxygenate all of the layers of water. The surface waters down to 10 meters are also well-oxygenated, being more available to wind-mixing and other activities on the surface. The lack of a correlation between dissolved oxygen and total phosphorus in these areas means that even if total phosphorus concentrations are high, contributing to excess organic matter and oxygen-depleting activities, the mixing action of the wind and waves compensate by creating sufficient oxygen for aquatic life.

However, correlations between volumetrically weighted average concentrations of total phosphorus versus dissolved oxygen in the peach and yellow grids showed very strong correlations. These zones of the reservoir do not have access to mixing actions of the wind and waves. Thus, all of the oxygen-depleting activities in these zones are more sensitive to excess phosphorus in the system. Figure 67 illustrates these correlations.

Looking at graphs showing the deepest measurements of total phosphorus in the deepest parts of the reservoir plotted with the dissolved oxygen measurements taken at the same spot as the phosphorus measurements seems to support this correlation (Figure 68.) Where total phosphorus shows the highest climb, there is a distinct dip in dissolved oxygen.

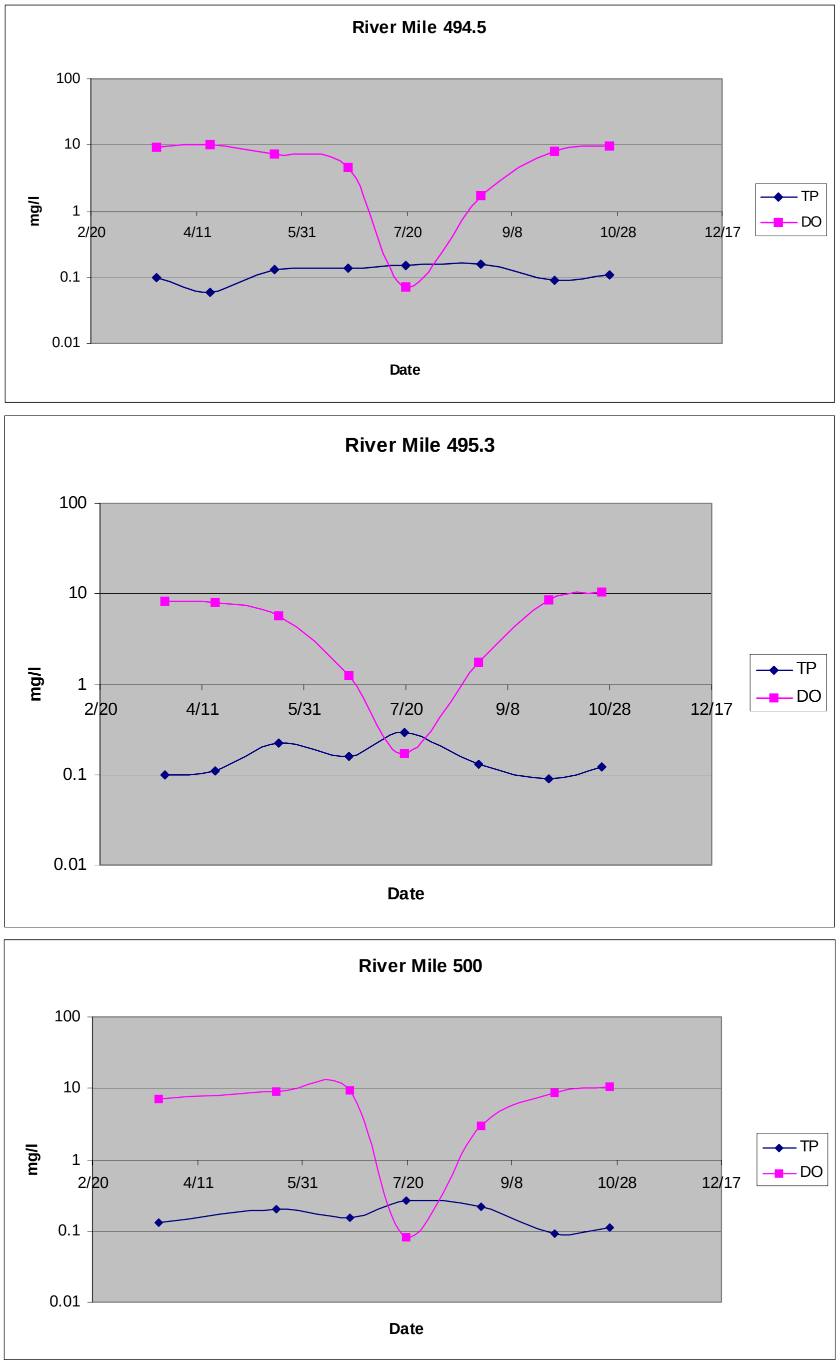

Figure 68. Deepest total phosphorus concentrations with corresponding dissolved oxygen concentrations

Chlorophyll-a

Evaluating chlorophyll-a concentrations is another way to assess water quality in the reservoir. Chlorophyll-a screening provides a method to measure algae in the system since most of the mass of an algal cell is the chlorophyll-a photosynthetic component. Algae seem to have three distinct blooms in the reservoir in May, June, and August (Figure 69).

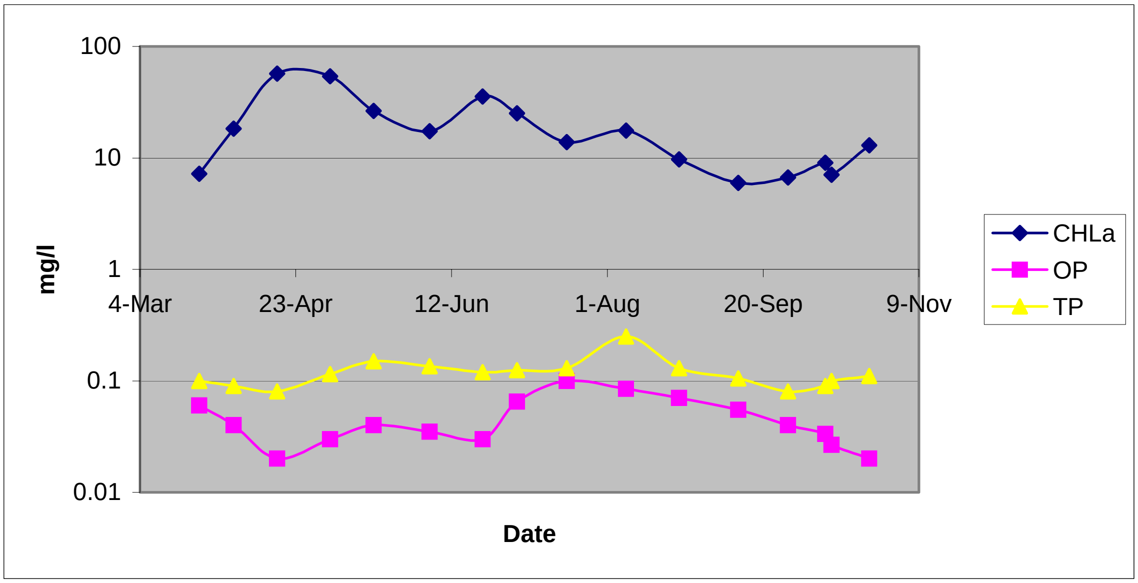

Figure 69. Chlorophyll-a, orthophosphorus, and total phosphorus data from C.J. Strike Reservoir

After the algal blooms occur, all phosphorus measurements in the water column consistently decrease. When the algal cells die, the phosphorus content of their bodies becomes part of the detritus by settling into the sediments. This means more phosphorus sinks to the bottom thus increasing the total loading. The algal blooms must be facilitated by the orthophosphorus coming in from the river upstream of the reservoir since only limited vertical mixing brings the high internal loading up out of the hypolimnion into the photic (light) zone of the surface waters to allow algal growth (Figures 70 and 71).

Nutrient Loading Analysis Summary

Overall, C.J. Strike reservoir is very slow to utilize its excess nutrient load. It is consistently eutrophic without major spikes. Phosphorus is the limiting nutrient. The reservoir is consistently stratified during the critical summer months. There is a very high internal loading of phosphorus being released from the sediments. With consistent stratification, there is limited vertical mixing of the phosphorus out of the hypolimnion and metalimnion. As a result, the metalimnetic dissolved oxygen concentrations frequently fall below 6.0 mg/L. If the phosphorus were not trapped on the bottom throughout the summer, the high internal load would affect nuisance algal growth to a greater extent. Algal blooms add to the internal phosphorus load by sinking to the bottom. The algal blooms are facilitated by the phosphorus coming in from the river upstream.

This type of stratified deep reservoir is fairly insensitive to load reductions. It will be slow to show improvement. However, phosphorus loading needs to be reduced to prevent further eutrophication. The phosphorus load reduction will have the biggest effect on the zone where all of the dissolved oxygen violations occur.

Total Dissolved Gas Loading Analysis – C.J. Strike Dam

C.J. Strike Reservoir is a 226,800 acre-foot impoundment of the Snake and Bruneau Rivers, located in Elmore and Owyhee counties. Located at Snake River mile 494.0, C.J Strike Dam was constructed in 1952. The primary function of the reservoir is to provide hydroelectric power, although it also serves other secondary functions such as irrigation and recreation. The plant's three generators have a total generating capacity of 82,800 kilowatts (Idaho Power Company 2004). The dam's spillway falls 68 feet at a gradient of approximately 44% to the Snake River. Located between the generators and the spillway is a section of land known as Scout Park. Figure 72 shows an overview schematic of the reservoir, dam, and downstream Snake River (Idaho Power Company 1998). Figure 73 shows the spillway on the north side of the dam.

The intent of this analysis is to use the available total dissolved gas (TDG) data to evaluate TDG conditions at established sampling locations in the Snake River below C.J. Strike Dam. The bases of this evaluation are the TDG requirements as they appear in the *Idaho Water Quality Standards and Wastewater Treatment Requirements (IDAPA 58.01.02)*. The TDG requirements can be found in section 250.01.b as follows:

> **The total concentration of dissolved gases not exceeding one hundred and ten percent (110%) of saturation at atmospheric pressure at the point of sample collection.**
>
> Section 300.01.a also specifies that *the director (of IDEQ) has the authority to specify the applicability of the gas supersaturation standard with respect to excess stream flow conditions.*

TDG Impact on Beneficial Uses

Chronically elevated total dissolved gas concentrations (above 110% of saturation) are known to have detrimental effect on aquatic life. High concentrations of gas dissolved in the water can result in *gas bubble trauma*, which occurs when air bubbles form in the circulatory system of resident fish (USA COE, 1999). "Gas bubble trauma results when the sum of the dissolved gas pressures exceeds the compensating pressures of hydrostatic head, blood, tissue, and water surface tension" (IPCo, 1998c, 1999b, 1999f).

Available Data for the C.J. Strike dam Area

A number of fish species susceptible to TDG illness are know to inhabit the Snake River in the vicinity of C.J. Strike dam. Most notably, Idaho Power Company has documented hatchery-grown rainbow trout and resident white sturgeon in the C.J Strike project area.

Total dissolved gas data below C.J. Strike dam are available on a weekly basis from March 3, 1999 through June 16, 1999 (n=15). Data were also collected during this period in the Snake River near Grandview (n=6). All measurements were collected by Idaho Power Company officials using a calibrated Hydrolab multi-parameter probe. Measurements were taken 0.3 meters below the water’s surface. Data were collected at four locations, as shown in Figure 72.

Observed Effects on Fisheries

Although sampling is limited to one day in the spring from 1988-1990 and 1994-1996, Idaho Power Company biologists have not observed signs of TDG induced illness in the trout population below C.J. Strike Reservoir (Idaho Power Company 2003). This appears to be the case in both spill and non-spill years.

Similar results have been noted for the white sturgeon population below C.J. Strike Dam. During Idaho Power Company’s 1994-1996 white sturgeon survey in the C.J. Strike-Swan Falls reach, no TDG trauma was noted in captured fish (Idaho Power Company 1998). Spill events occurred in 1995 and 1996, but not in 1994. At 130% of period of record (POR), 1996 was a particularly high flow year meaning elevated spill rates likely occurred. Even so, TDG induced trauma was not noted.

TDG Data Analysis

The TDG data from below C.J. Strike dam were analyzed in a stepwise fashion to derive a data set that best represents the TDG conditions affecting the local aquatic life community (primarily fish). Table 33 outlines the steps used to derive the final data set for which compliance with the TDG standard was based.

Table 33. Steps used to derive the final TDG data set for compliance purposes

<table>
<tr><th>Step</th><th>Objective / Rationale</th></tr>
<tr><td>Used the bridge directly below the dam as the compliance point</td><td>While not required to allow a mixing, DEQ chose to establish a compliance point approximately 500 yards downstream from the dam (sites #3 and #4, at the bridge). Therefore, the data from sites #1 and #2 were not used in the analysis.</td></tr>
<tr><td>Established a width integrated data set at the bridge</td><td>Since bridge data were available from the spill side of the channel (site #3) and the powerhouse side of the channel (site #4), the data were composited, via flow weighting, into a single data set for compliance determination purposes.</td></tr>
<tr><td>Flow weighted the site #3 and site #4 TDG data</td><td>For the March 3, 1999, through June 16, 1999 (n=15), period of record the powerhouse flows show relatively little variation (Figure A), whereas the spill flows show a significant level of variation (Figure B).

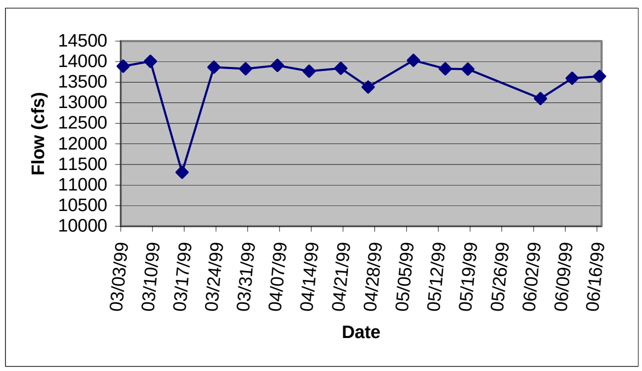

Figure A. Powerhouse Flows

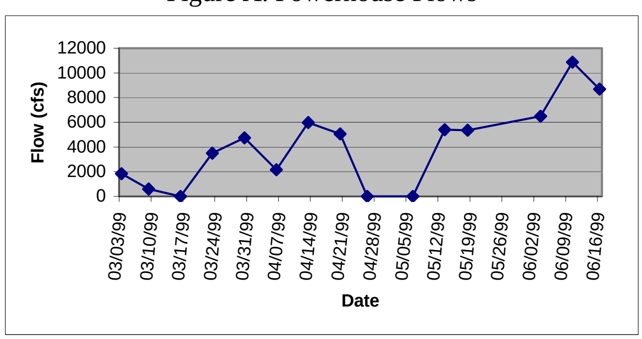

Figure B. Spill Flows

To account for this variability in flows, their effect on TDG, and to prevent one data set from statistically outweighing the other, the data sets were flow weighted.</td></tr>
<tr><td>Compared the flow weighted TDG data to the TDG standard</td><td>The flow weighted TDG data were compared to the TDG standard as it appears in IDAPA 58.01.02. 250.01.b. The 10% exceedence guidance from Grafe 2002 was used to determine compliance (10% of the data can exceed the criteria).</td></tr>
</table>

Table 34 shows the site #3 and #4 TDG data, the spill and powerhouse flows, the total flow at Strike Dam Bridge and the flow weighted TDG at Strike Dam Bridge. Figure 74 shows the site #3 and #4 TDG data as compared to the flow weighted TDG at Strike Dam Bridge.

Table 34. Flow weighted TDG at Strike Dam Bridge

Date	Site #4 TDG (%Sat)	Powerhouse Flow CFS	Site #3 TDG (%Sat)	Spill Flow (cfs)	Total Flow	Flow Weighted Ave TDG (%Sat)
03/03/99	101	13887	110	1838	15725	**102**
03/09/99	101	14004	104	600	14604	**102**
03/16/99	105	11309	104	0	11309	**105**
03/23/99	108	13861	113	3500	17361	**109**
03/30/99	105	13822	115	4750	18572	**108**
04/06/99	103	13906	111	2148	16054	**104**
04/13/99	106	13763	117	5971	19734	**109**
04/20/99	108	13835	116	5058	18893	**110**
04/26/99	106	13385	105	0	13385	**106**
05/06/99	100	14032	100	0	14032	**100**
05/13/99	104	13822	118	5400	19222	**108**
05/18/99	103	13815	118	5350	19165	**107**
06/03/99	102	13105	118	6492	19597	**108**
06/10/99	105	13600	121	10869	24469	**112**
06/16/99	104	13646	104	8700	22346	**104**

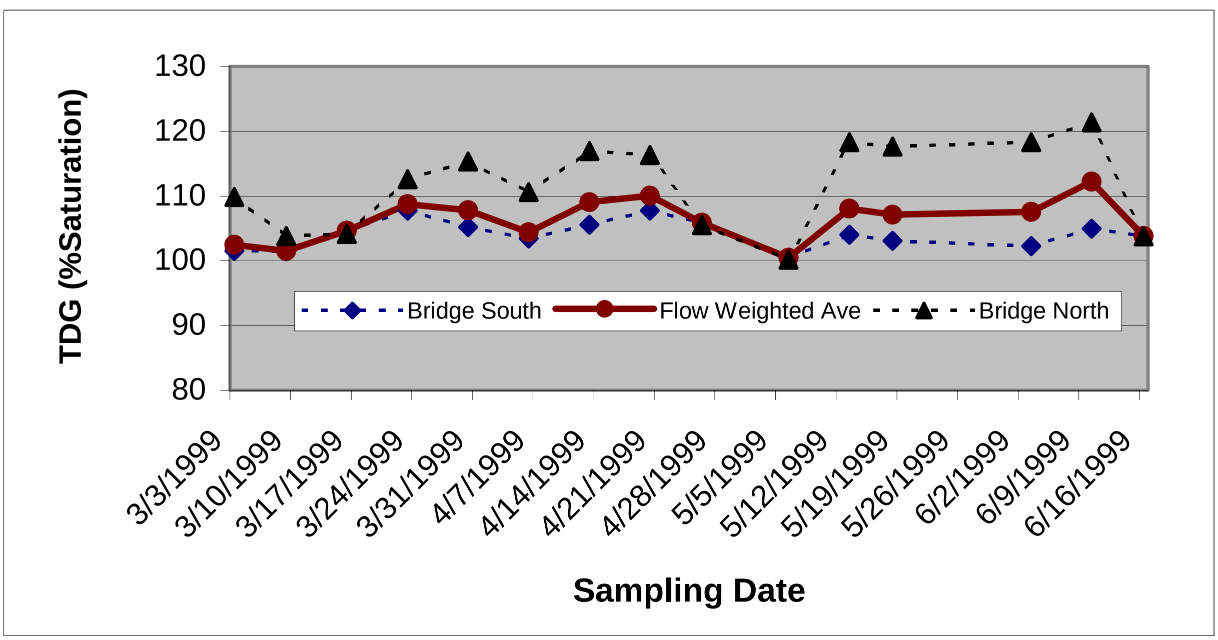

Figure 74. Flow weighted TDG at Strike Dam Bridge as compared to site #3 and site #4 data

As shown in Table 34 and Figure 74, the cross-sectional flow weighted TDG values at the bridge exceed the 110% criteria very infrequently. A single exceedence of 112% occurred on June 10, which was also the day when the highest spill occurred (10,869 cfs). This single exceedence accounts for 7% of the data set, and as such, does not constitute a violation of the TDG water quality standard (less than 10% exceed).

Excess River Flow Considerations

As noted above in the standards discussion, section 300.01.a of the *Idaho Water Quality Standards and Wastewater Treatment Requirements* specify that the director (of IDEQ) has the authority to specify the applicability of the gas supersaturation standard with respect to excess stream flow conditions.

Spill from C.J. Strike Reservoir is largely dependent on water-year and, therefore, does not occur every year (Idaho Power Company 1998). In low flow years, frequent spills beyond the spring are typically not necessary. In higher flow years when spill does occur, the powerhouse is normally at full operational capacity (~15,500 cfs). The spills occur as a function of operating the reservoir as a run-of-the-river.

The available data show that the flow weighted TDG at the bridge may exceed 110% when spill flows exceed 10,000 cfs. Figure 75 shows the correlation between the total flow of the river and TDG at the bridge. The total flow is a combination of powerhouse flows (usually always near 14,000 cfs) and spill flows.

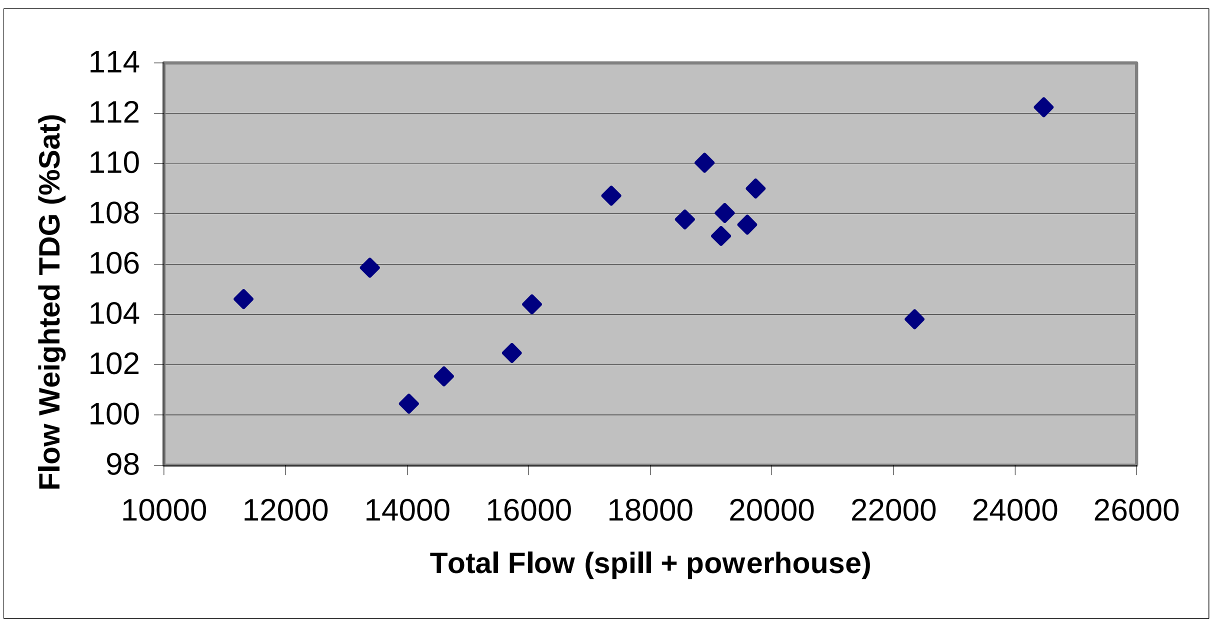

Figure 75. Correlation between total flow and flow weighted TDG at the bridge

The relationship between total flow and flow weighted TDG shown in Figure 75 is based on three months data from 1999, which was a high flow year (141% of POR). Due to the low number of data points, there is some uncertainly as to the total flow/TDG relationship beyond a total flow of 25,000 cfs. That is, TDG values may continue to rise as flows exceed 25,000 cfs, or, TDG values may plateau at some level of total flow. To account for this data gap, the Final Environmental Impact Statement recommended that Idaho Power Company continue to monitor TDG when spills exceed 10,000 cfs to better define the relationship (FERC 2002). This strategy is intended to provide better data to assess the effects of project operation on TDG and determine whether corrective actions are necessary to eliminate violations of the state TDG standard (FERC 2002).

TDG Summary and §303(d) Listing Recommendation

The flow weighted TDG data calculated at the bridge directly below C.J. Strike dam show that the 110% saturation standards is exceed 7% of the time, when spill flows exceed 10,000 cfs. Due to the infrequency of this spill volume and because no TDG induced illness has been noted in local aquatic life, DEQ recommends not listing TDG as a pollutant of concern on the §303(d) list. Since 1999 was a high flow year (141% of POR), this recommendation contains some level of conservativeness. However, since the recommendation is based on only three months data collected from a single year, DEQ agrees with the Federal Energy Regulatory Commission's recommendation to monitor TDG when spills exceed 10,000 cfs.

Conclusions and Status of Beneficial Uses in C.J Strike Reservoir

The pesticides analysis shows that the calculated t-DDT and dieldrin water column concentrations and the measured concentrations for several other pesticides of interest in C.J. Strike Reservoir do not exceed the target concentrations for cold water aquatic life or domestic water supply beneficial uses. As such, pesticides are not impairing these beneficial uses and TMDLs are not recommended.

The nutrient analysis shows that there is limited vertical mixing of the phosphorus out of the hypolimnion and metalimnion. As a result, the metalimnetic dissolved oxygen concentrations frequently fall below 6.0 mg/L during the critical summer months. While this type of stratified deep reservoir is fairly insensitive to load reductions and will be slow to show improvements, a TMDL to reduce phosphorus loading needs to be prepared to help prevent further eutrophication. The phosphorus load reduction will have the biggest effect on the metalimnion where nearly all of the dissolved oxygen violations occur.

The analysis of TDG in the Snake River below C.J. Strike Dam shows that the flow weighted TDG directly below C.J. Strike Dam exceeds 110% very infrequently (7% of the time). Additionally, no excess TDG induced illness has been noted in the fish below the dam. Based on the low exceedance percentage and a lack of aquatic life impairment, TDG does not appear to be impairing beneficial uses and a TMDL is not recommended.

Table 35 summarizes the beneficial use support status for C.J. Strike Reservoir as it pertains to the pollutants of concern and outlines the pollutant(s) for which TMDLs will be developed.

Table 35. Summary of the water quality assessments for C.J. Strike Reservoir, HUC 17050101

Pollutant of Concern	Impaired Beneficial Use(s) [1]	TMDL Required	Comments
Pesticides	None	No	--
Nutrients	CWAL	Yes	C.J. Strike Reservoir will receive a phosphorus load allocation based on in-flowing conditions. Additional management will be required to meet the dissolved oxygen criteria. See Chapter 5 for details.
Total Dissolved Gas	None	No	--

[1]CWAL: cold water aquatic life

Additional Resource Management Considerations

Idaho Power Company has found the Idaho Springsnail (*Pyrgulopsis idahoensis*) in both the Snake River and Bruneau River arms of C.J. Strike Reservoir (Idaho Power Company 1998). However, additional work has suggested that the populations inhabiting C.J. Strike Reservoir may be more appropriately classified as *Pyrgulopsis robusta*, which is an un-listed (by the Endangered Species Act) subgenus (Hershler and Liu 2004). Idaho Springsnails are cold water stenotherms (prefers cold water) typically restricted to cold springs and spring-fed locations (Frest and Johannes 2000). However, Idaho Power Company has located Springsnails in water temperatures exceeding 22^{o}C (Idaho Power Company 1998).

Additionally, white sturgeon (*Acipenser transmontanus)* occur in C.J. Strike Reservoir. Most of the sturgeon were collected within river miles 504 and 505, which is near the Cove Arm (refer to Figure 50) (Idaho Power Company 1998).

In the case of C.J. Strike Reservoir, management of the Idaho Springsnail and white sturgeon is not in the purview of the TMDL. TMDL allocations alone are not comprehensive enough to fully consider the propagation and growth dynamics of either species. A more holistic management strategy for these species is already in place and is recognized by federal agencies responsible for managing threatened and endangered species as well as FERC and Idaho Power Company.

Regarding management of the Idaho Springsnail, Idaho Power Company entered into a settlement agreement with the U.S. Fish and Wildlife Service in February 2004. The two parties agreed that additional studies and analysis were desirable in order to more accurately assess the effects, if any, that the Mid-Snake and C.J. Strike projects may have on one or more of the listed snail species. The parties agreed upon an operational regime for the projects that will both permit six years of studies and analyses of various project operations on the listed snail species and provide interim protection of the listed species. After the studies are completed, Idaho Power Company and the U.S. Fish and Wildlife Service intend to jointly develop a plan that will address project operations and the protection of listed snails for the remainder of new license terms (Idaho Power Company 2004).

Regarding the white sturgeon, Idaho Power Company has initiated a white sturgeon conservation plan. The plan is intended to serve as a master plan for guiding the implementation of feasible mitigation measures for Snake River white sturgeon populations impacted by Idaho Power Company's hydroelectric projects. These measures are designed to help ensure the species' long-term persistence and restore opportunities for beneficial use. This plan outlines proposed measures and strategies for Snake River white sturgeon that IPC would implement once the WSCP were accepted and new project licenses issued by FERC (Idaho Power Company 2003).

2.5 Subbasin Assessment Summary

Total maximum daily loads were developed for four water body segments (nine assessment units) in the King Hill-C.J. Strike watershed. Table 36 summarizes the stream segments addressed in this assessment and the actions that will be taken as a result of the assessment.

Table 36. Summary of King Hill-C.J Strike Reservoir subbasin assessment conclusions

Water Body	§303(d) Boundary[1]	Listed Pollutants	Proposed Action
Snake River	King Hill to Highway 51 Bridge (Loveridge Bridge)	Sediment	TMDLs for sediment and nutrients
C.J. Strike Reservoir	Entire Reservoir	Pesticides, Nutrients	TMDL for nutrients with no in-reservoir reduction requirements. Additional management to meet the dissolved oxygen criteria De-list pesticides Do not list TDG
Alkali Creek	Headwaters to Snake River	Sediment	De-list sediment
Bennett Creek	Headwaters to Snake River	Unknown	De-list for unknown
Browns Creek	Headwaters to Snake River	Sediment	De-list sediment
Cold Springs Creek	Ryegrass Creek to Snake River	Unknown	TMDL for sediment
Deadman Creek	Headwaters to Snake River	Sediment	De-list sediment
Little Canyon Creek	Headwaters to Snake River	Sediment, Flow Alteration	TMDL for sediment, no action for flow alteration
Ryegrass Creek	Headwaters to Cold Springs Creek	Sediment	De-list sediment
Sailor Creek	Headwaters to Snake River	Sediment	De-list sediment

[1] The §303(d) boundaries are not always the same as the boundaries for which TMDLs were developed. In many cases impairment does not exist throughout the entire segment, or, the segment is split for other reasons. Chapter 5 discusses the TMDL boundaries in more detail.